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Learning from Errors and Error Management Culture in Teams

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(2020)

DOI (TUprints): <https://doi.org/10.25534/tuprints-00013225>

Lizenz:



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Publikationstyp: Ph.D. Thesis

Fachbereich: 03 Department of Human Sciences

Quelle des Originals: <https://tuprints.ulb.tu-darmstadt.de/13225>



TECHNISCHE
UNIVERSITÄT
DARMSTADT

Learning from Errors and Error

Management Culture in Teams

Inaugural-Dissertation

in Fulfillment of the Requirements for the
Degree of Doctor philosophiae (Dr. phil./PhD)

Department of Human Sciences

Technische Universität Darmstadt

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Asia School of Business, Malaysia)

Darmstadt, 2020

Horvath, Dorothee: Learning from Errors and Error Management Culture in Teams

Darmstadt, Technische Universität Darmstadt,

Published in TUpriints: 2020

URN: urn:nbn:de:tuda-tuprints-132251

Date of viva voce: June 30th, 2020

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Acknowledgements

I cannot begin to express my deepest gratitude to Prof. Dr. Nina Keith and Prof. Dr. Michael Frese, who gave me the chance to work on a brilliant project. You provided me not only with knowledge, guidance, feedback, and support, but with encouragement and patience throughout the duration of this research project. I have been extremely lucky to have you as my supervisors.

I would also like to extend my deepest appreciation to Alexander Klamar from Leuphana Universität Lüneburg. We talked about this a couple of times, but I still cannot believe how lucky I am to have you as my project-partner and friend. Thank you for the long talks – you always helped, supported, encouraged, and nurtured me (I am sorry for being such a crybaby). We did it!

Completing this work would have been all the more difficult were it not for the support and help provided by my (former and current) colleagues at Technische Universität Darmstadt. Dr. Christian Wolff, Dr. David Hoppe, Florian Kadner, Jessica Höpfner, and Nils Neupärtl, thank you! In particular, I would like to thank Dr. Rosemarie Gauglitz, who encouraged and inspired me to take part in this research project. Furthermore, I am extremely grateful to Sabine Ortler, who helped me to overcome all administrative barriers and was always ready to lend a sympathetic ear. My thanks should also go to Prof. Dr. Wolfgang Ellermeier, Prof Dr. Bernhard Schmitz, Prof. Dr. Stephanie Pieschl, Dr. Udo Keil, Dr. Regine Angert, Inge Galinsky, as well as to the faculty of the National University of Singapore, who hosted me for a short-term research stay.

I would like to extend my sincere thanks to the students who assisted me, amongst others, in data collection and ratings of qualitative data. Thanks to Alexander Böhm, Anna Küster, Bilal Husein, Carlos Böhm, Carolin Koch, Fiona Buckley, Ina Schmidt, Iris Hoffmann, Jakob Johann, Joana Schadt, Katharina Freitag, Laura Margolf, Laura Reczek, Lisa Wegerich, Mai Anh Nguyen, Manuel Groß, Marcus Fehr, Martha Kreß, Michelle Benkel, Stephanie Neidlinger, and Verena Jahn. I would also like to recognize the time and effort of the participants of our studies.

Most of all, I would like to express my deepest gratitude to my father, mother, Botond, and Franci. These four years were tough and bittersweet. Thanks for always being there for me and encouraging me. I could not have done it without you. Thanks go also to Lilla, my sisters, my family, and close friends.

Abstract

The topic of errors has received increasing attention in recent years. Most errors are easily corrected, however, some of them result in severe negative consequences, such as extensive economic or societal damage, or even the loss of lives. The negative connotation one has when thinking about errors is therefore not surprising. Errors, however, can even have positive consequences, such as innovation, performance, or learning. It is widely acknowledged that errors can be a rich source of learning. Nevertheless, little is known about which errors prompt learning the most. We believe that the extent of learning from errors depends, among others, on error characteristics and the context in which the error was made. In particular, we propose that more learning from errors occurs when error consequences are severe (as opposed to mild), when the error was made by oneself (as opposed to someone else), and when more error management culture is experienced. We also expect differences between countries in learning from error.

In Chapter 2 of this dissertation, we focus on the role of error characteristics in learning from errors. To test whether the amount of learning from errors depends on the severity of error consequences and the agent who made the error, we conducted two vignette experiments (Study 1, $N = 121$ from Germany; Study 2, $N = 118$ from the United States) in which participants responded to error scenarios that happen to employees at work. As expected, people learned more from errors in terms of affective error learning (self-reports) and cognitive error learning (recall of error situations) if consequences were severe (Study 1 and Study 2) and if the error was made by themselves (Study 2).

In Chapter 3 of this dissertation, we sought to replicate the results we found in Chapter 2 and extend them by investigating the role of contextual factors in learning from errors (only affective error learning). For this purpose, we conducted vignette experiments in the United

States, Germany, and Hungary ($N = 588$). We found that more affective learning from errors occurred when more error management culture was experienced. Furthermore, we found differences between countries in affective learning from errors such that participants from the United States learned more from errors than participants from Hungary or Germany. This relationship was mediated by error management culture. We were also able to replicate the results regarding severity of error consequences and agent (who made the error).

In Chapter 4 of this dissertation, we shift the focus from the individual to the team and investigate whether error management culture not only benefits learning from errors (as shown in Chapter 3), but also performance-related outcomes. In particular, we conducted an experiment with teams ($N = 180$ participants (60 triads)), in which we sought to replicate the pattern of results concerning error management culture and performance found in previous field studies. Furthermore, we aimed to induce an error management culture. We were able to induce an error management culture by fostering a positive view on errors and exploration. We also found error management culture to benefit performance in a creative problem-solving task. However, the effects of our manipulations persisted over time only when culture strength (i.e., agreement about culture between group members) was high.

With our studies, we aim to contribute to a better exploitation of the rich information inherent in errors. Our insights can be used as a starting point to develop interventions that aim at improving the way people deal with errors in organizations, as well as to raise attention to the importance of culture specific issues.

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Part I

General Introduction

1

Learning from Errors and Error Management Culture: An Overview

“The credit belongs to the man who is actually in the arena; whose face is marred by dust and sweat and blood; who strives valiantly; who errs, who comes short again and again, because there is no effort without error or shortcoming.”

(Theodore Roosevelt)

Errors are part of being human and everyday life. We fall while learning to walk, we try and err while learning new skills, until we succeed. It is no different in working life: we make errors on a daily basis. Do you recall writing a term paper for school or making a presentation for work and checking it for typos? And after sending it or printing it, finding another typo? Naturally, we try to prevent and avoid errors from happening. However, despite best efforts, errors may never be completely avoided (Reason, 1997; Zhao & Olivera, 2006). In a rapidly changing world, where organizations' main goal is to be more

profitable, efficient, and innovative, in sum more successful than other organizations, one has to acknowledge, that “errors are fundamental for human development and organizations” (Frese & Keith, 2015, p. 662). Thus, rather than narrowly focusing on error prevention, approaches to actively manage errors before negative error consequences unfold should prevail. Errors do not inevitably lead to negative consequences, but even have positive functions as they may foster learning and innovation (Bauer, Gartmeier, & Harteis, 2010; Baumard & Starbuck, 2005; Edmondson, 1996, 1999; Frese & Keith, 2015; Reason, 1990; Sitkin, 1992; van Dyck, Frese, Baer, & Sonnentag, 2005; Zhao, 2011).

Errors and Learning from Errors

An *error* can be defined as an unintentional deviation from a goal, rule, or standard (e.g., Frese & Keith, 2015; Frese & Zapf, 1994; Reason, Manstead, Stradling, Baxter, & Campbell, 1990). For example, when an employee submits a report containing miscalculations due to insufficient knowledge without noticing, s/he made an error. Some errors, such as typos or misspells can be easily corrected. Other errors can result in severe negative consequences, such as substantial economical or societal damage, and even the loss of lives.

Errors should be distinguished from *violations*, *inefficiencies*, and *failures*. A violation is an intentional deviation from a norm or goal (Frese & Keith, 2015). Inefficiencies are actions where the goal is achieved, however, only with detours (Frese & Keith, 2015). Failures refer to negative outcomes (Frese & Keith, 2015). “Errors can be detected and corrected immediately” and therefore do not inevitably lead to negative error consequences, thus, to failures (Frese & Keith, 2015, p. 663). Errors can even lead to positive consequences, such as learning (e.g., always checking if the report contains up-to-date information).

Action regulation theory (e.g., Frese & Zapf, 1994; Hacker, 1973, 2003; Zacher & Frese, 2018) considers humans as active agents. Humans act and interact with the (work) environment. While doing so, humans develop and refine their mental models of the system or

the task (Frese & Zapf, 1994; Hacker, 1973, 2003; Heimbeck, Frese, Sonnentag, & Keith, 2003). In that sense, erroneous actions are critical for learning, as they serve important informatory functions. Errors provide negative but informative feedback that predicts learning, even more so than positive feedback (Frese & Keith, 2015; Zacher & Frese, 2018). Other scholars agree that errors can be a rich source of learning (Cannon & Edmondson, 2005; Dormann & Frese, 1994; Edmondson, 1996; Ellis, Carette, Anseel, & Lievens, 2014; Frese & Keith, 2015; Heimbeck, et al., 2003; Ivancic & Hesketh, 1995/1996; Keith & Frese, 2008; Sitkin, 1992). Errors signify that something went wrong and indicate that some (re)action is required (Ivancic & Hesketh, 1995/1996; Heimbeck et al., 2003; Keith & Frese, 2011). Errors provide a deeper insight into the system in which the error occurred, and contribute to exploration and experimentation, as well as the development of new ideas (Dormann & Frese, 1994; Frese & Keith, 2015). In most cases, errors occur unexpectedly – errors are “negative surprises” (Cannon & Edmondson, 2005, p. 300) that catch attention. The amount of attention devoted to errors may evoke a deeper cognitive processing of the errors (Craig & Lockhart, 1972). Thereby, errors foster learning.

However, it is unclear which types of errors foster learning the most, although it seems obvious that errors differ in the extent to which they affect learning (e.g., Sitkin, 1992; Cannon & Edmondson, 2005). Only by understanding which factors determine learning from errors can organizations develop appropriate interventions to improve the way people deal with errors. In this dissertation, one of our aims is to investigate to what extent learning from errors depends on error characteristics and the context in which the error was made. The following research questions regarding learning from errors are addressed in this dissertation:

Research questions 1: Do error characteristics and the context in which the error happened affect the amount of learning from errors? Specifically, does the amount of learning from errors depend on error characteristics, such as severity of error

consequences or the agent who made the errors, and on contextual factors such as the organizational culture (i.e., error management culture) or country?

Error Management and Error Management Culture

General strategies of how to deal with errors can be roughly classified in either error prevention or error management approaches (Frese, 1991, 1995; Goodman, Ramanujam, Carroll, Edmondson, Hofmann, & Sutcliffe, 2011). Error prevention focuses on eliminating error before they could even occur (see Figure 1.1 arrow between “action” and “errors”). Yet, despite best efforts to prevent errors, it is impossible to eliminate errors completely (e.g., Reason, 1997). Purely relying on error prevention, thus, has its limits. Rather, error prevention should be supplemented by strategies that are directed at effectively dealing with errors after they have occurred and before negative consequences unfold (Frese, 1991, 1995). *Error management* is a perspective towards errors that distinguishes errors from their consequences. *Error management* is directed at effectively dealing with errors after they have occurred but before negative consequences can unfold (see Figure 1.1 arrow between “errors” and “consequences”). Moreover, error management aims to foster positive consequences that may result from errors, such as long-term-learning, innovations, and performance (e.g., Sitkin, 1992; Keith & Frese, 2011, 2015; Fischer, Frese, Mertins, & Hardt-Gawron, 2018).

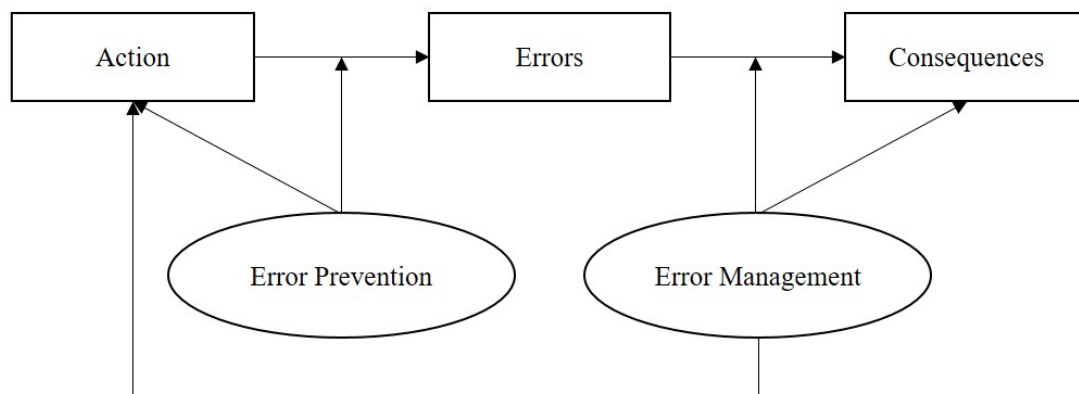


Figure 1.1. Error prevention and error management in the action-error cycle (adapted from Hofmann & Frese, 2011, p. 31).

As every organization is confronted with the potential of making errors, most organizations implicitly or explicitly adopt some shared norms, values, practices, and procedures of dealing with errors—i.e., a culture (Schein, 2004) of dealing with errors or error culture. One particular form of such an error culture is the concept of error management culture which applies the principles of error management to the unit level. The idea is that members of a unit (e.g., an organization, a department or a team within an organization) share a system of norms and values as well as common practices and procedures (Schein, 2004) directed at error management (van Dyck et al., 2005). Error management culture is a culture in which team members do not have to fear being blamed for errors they have made, and where exploration and experimentation is enabled. Error management culture has been shown to benefit organizational outcomes such as safety, innovativeness, and performance (Hofmann & Mark, 2006; Keith & Frese, 2011; van Dyck et al., 2005; Fischer et al., 2018). However, the question whether and how an error management culture can be induced remained unanswered. Understanding how an error management culture may be induced does not only contribute to our theoretical knowledge but is also relevant for practitioners in order to understand drivers of change. The following research questions regarding error management culture are addressed in this dissertation:

Research questions 2: Is it possible to induce an error management culture in teams? If so, how? Can we replicate the beneficial effect of error management culture on performance found in field studies under standardized experimental settings?

Overview of the Present Research

The following three chapters aim at answering the aforementioned research questions. Chapter 2 and Chapter 3 focus on our first category of research questions, namely the error characteristics and contextual factors that may affect learning from errors. Chapter 4 focuses on our second category of research questions, namely whether and how error management culture can be induced. Each chapter comprises several empirical studies and test specific hypotheses regarding learning from errors or error management culture. While the chapters refer to one another, they contain separate theoretical introductions, method and results sections, and discussions. This allows readers to read them independently from each other.

Overview of Chapter 2

While scholars agree that errors can be a rich source of learning (e.g., Dormann & Frese, 1994; Frese & Keith, 2015; Heimbeck, et al., 2003; Madsen & Desai, 2010; Zakay, Ellis, & Shevatsky, 2004), research is scarce on error characteristics that make learning from errors more or less likely. In Chapter 2, we thus focus on error characteristics that may influence the amount of learning from errors, namely on (a) severity of error consequences and (b) the agent who made the error. We assume that severity of error consequences affects learning from errors positively, that is the more severe the consequences, the more learning from errors will occur. Our assumption is based on the fact that humans devote more attention to negative than to positive information (Vaish, Grossman, & Woodward, 2008; Zakay et al., 2004). Also, errors with mild consequences may be more easily overlooked or ignored (Baumard & Starbuck, 2005). Furthermore, we assume that more learning from errors occurs when the agent of the error is oneself (i.e., the error is made by oneself) as opposed to someone else. Although people can learn from observing others (Bandura, 1986), an error that was made by oneself should have high personal relevance, which attracts a higher degree of attention (e.g., Petty, Cacioppo, & Goldman, 1981).

While other error characteristics may also be important for learning from errors, we chose to focus in particular on these two error characteristics for the following reasons. First, if severity of error consequences would affect learning from error in our study, this would underline the clear distinction error management theory makes between the error and its consequence (Frese & Keith, 2015; Hofmann & Frese, 2011). Second, as previous studies regarding severity of error consequences were mostly field studies (e.g., Homsma, van Dyck, De Gilder, Koopman, & Elfring, 2009; Zakay et al., 2004) more systematic research is needed. Third, both theory (Bandura, 1986) and empirical evidence (Kim & Miner, 2007) suggest that learning from others' errors is possible. Still, the error characteristic agent (who made the error) has not been explicitly considered in previous research.

In two studies (Study 1: $N = 121$ work-experienced adults from Germany ($M_{age} = 36.92$ years, $SD_{age} = 15.09$; 61.2 % female); Study 2: $N = 118$ work-experienced adults from the United States ($M_{age} = 35.76$ years, $SD_{age} = 10.54$; 35 % female)), we experimentally tested our assumptions by prompting participants to react to error scenarios (vignettes) that reflect situations typical for employees at work (within-participants design). The baseline vignette that described the error and the situation in which the error occurred was identical across experimental conditions, but the consequences that developed from the same error and the agent who made the error varied. We counterbalanced the order of presentation and scenario-factor combinations to control for potential material effects. After each error scenario participants had to respond to manipulation checks and indicate how much they learned from the error (i.e., affective error learning; 3 of the 4 items of the subscale “learning from errors” of the Error Orientation Questionnaire (EOQ; Rybowskiak, Garst, Frese, & Batinic, 1999)). After a filler task, participants had to recall as many of the previously presented error scenarios in as much detail as possible (i.e., cognitive error learning). As guiding questions, we asked for the

agent who made the error, the error situation, as well as the error consequence. Two raters independently coded whether participants correctly recalled the error scenarios.

In line with our assumptions, severity of error consequences increased learning from errors: participants not only reported to learn more (affective error learning) from errors with severe consequences than mild consequences, but they also recalled error situations (cognitive error learning) better when error consequences were severe. Participants also learned more from an error (only affective error learning) if the error was made by themselves as opposed to by someone else. With our studies, we aim to contribute to the relatively small body of research regarding error characteristics that may affect learning. Understanding the error characteristics that influence learning from errors enables a better exploitation of the rich information inherent in errors.

Overview of Chapter 3

In Chapter 3, we sought to replicate the results from Chapter 2 regarding error characteristics and learning from errors, but also to extend them by investigating the role of contextual factors in learning from errors. In particular, we wanted to investigate (a) the relationship of organizational error culture (i.e., shared norms and beliefs about errors) and learning from errors, and (b) whether there are country differences in error management culture, and (c) learning from errors. We also explored whether (d) potential country differences in learning from errors may be due to differences in error management culture.

Both theoretical (e.g., Gelfand, Frese, & Salmon, 2011) and empirical evidence (e.g., Davis, Bryant, Tedrow, Liu, Selgrade, & Downey, 2005; Helmreich & Merritt, 1998) suggest that the way people deal with errors varies across countries. Learning from errors may thus differ as well. We deem the GLOBE (House, Hanges, Javidan, Dorfman, & Gupta, 2004) dimension of uncertainty avoidance to be particularly important for the way people deal with errors (i.e., error management culture) and consequently for learning from errors. The way

people deal with uncertainty may influence how people consider and deal with occurring errors (i.e., error management culture), as errors are always, to a certain extent, ambiguous. This, in turn, may influence how much learning from errors occurs. In countries low in uncertainty avoidance, errors may be evaluated more positively (Gelfand et al., 2011). A positive evaluation of errors may then make error management culture more likely. In an error management culture where errors are considered as chances to learn, learning should be fostered (e.g., Frese & Keith, 2015). As there is an ongoing debate about whether country rankings can be used to predict individual behavior (e.g., Bond, 2002; Brewer & Venaik, 2012, 2014; Kirkman, Lowe, & Gibson, 2006), we exercise caution and decided to put forth open research questions regarding country differences in favor of concrete hypotheses.

To test our assumptions, we studied samples ($N = 588$) of work-experienced adults of three different countries, namely the United States, Hungary, and Germany, and assessed error management culture. We chose these countries as they score differently on the GLOBE uncertainty avoidance societal practices dimension (Hungary is low on uncertainty avoidance, the United States range in the middle, and Germany scores high; de Luque & Javidan, 2004). Design and procedure of Chapter 3 were similar to those of the studies from Chapter 2, with the following differences. First, we included the country in which the sample was collected in as a between-participants factor. Second, the present study only employs the affective error learning measure, as Chapter 2 provided evidence that the affective error learning measure is an adequate proxy for learning from errors. Third, the present study used three levels of the experimental factor agent (self, close colleague [i.e., from the same company], and distant colleague [i.e., from a different company]). According to social identity theory (Tajfel & Turner, 2004), there is a “tendency to favor the in-group over the out-group in evaluations and behavior” (p. 281). This would imply that the degree of learning that occurs might not only depend on the dichotomy (self and other) but may vary gradually with the agent. As a result of

in-group favoritism, learning might be higher from errors made by an in-group member (e.g., close colleague), than from errors made by an out-group member (e.g., distant colleague).

We obtained the same pattern of results regarding error characteristics as in Chapter 2: the amount of learning from errors depended on the severity of error consequences and the agent who made the error. Furthermore, we found error management culture to be beneficial for learning from errors. We also found differences between countries in error management culture and learning from errors in that participants from the United States reported more error management culture and learned more from errors than participants from Hungary or Germany. The relationship between country and learning from errors was mediated by error management culture. Only by understanding which error characteristics and how the cultural context determine learning from errors can organizations develop appropriate interventions to improve learning from errors.

Overview of Chapter 4

In Chapter 3, we demonstrated, *inter alia*, that error management culture is beneficial for learning from errors. In Chapter 4, we shift the focus from the individual to the team level, and explore whether error management culture is not only beneficial for learning from errors, but also for performance. When error management culture is high, team members do not have to fear blame or punishment and learning from errors and open communication about errors is encouraged (van Dyck et al., 2005; Frese & Keith, 2015). These enable quick error detection, damage-control, exploration and experimentation, which in turn may foster performance (van Dyck et al., 2005; Dormann & Frese, 1994; Keith & Frese, 2008, 2011). Previous studies have already investigated the effect of error management culture on performance and found error management culture to be beneficial for performance-related outcomes (e.g., Fischer et al., 2018; van Dyck et al., 2005; Hofmann & Mark, 2006). However, these studies were field studies. While field studies have the advantage of high ecological validity, the higher

ecological validity can come at the expense of lower internal validity. Furthermore, these studies left the question open whether and how an error management culture can be induced in teams. While literature on organizational culture suggests that culture can be established and changed (e.g., Schneider & Reichers, 1983; Sathe & Davidson, 2000), the question still remains how an error management culture can be established. In our study, we thus aimed to induce an error management culture in teams and also aimed to replicate the pattern of results concerning error management culture and performance found in field studies under standardized experimental conditions. For this purpose, we developed two different error management culture manipulations and conducted a laboratory experiment with newly formed teams ($N = 180$ participants (60 triads)). Our manipulations focused on how participants should deal with errors in the process of the team task. We developed one error management culture manipulation based on normative social influence. We chose to base our manipulation on normative social influence because normative social influence is considered as a key factor in the formation of organizational culture (Ashforth, 1985). Also, several studies demonstrated the power of normative social influence on people's behavior (e.g., Sherif, 1935; Deutsch & Gerard, 1955; for a review see Cialdini & Goldstein, 2004). Groups that were manipulated with an error management culture manipulation based on normative social influence received error management culture principles and practices as written descriptive norms. We developed another manipulation based on error management training instructions. We chose to base our manipulation on error management training instructions because error management training has been shown to be an effective training method and to be beneficial for performance (e.g., Heimbeck et al., 2003; Keith & Frese, 2005; for a meta-analysis see Keith & Frese, 2008). Error management training, however, focuses on the individual level. In our study, we aimed at inducing error management culture by using error management training instructions but applying them to the team level. Groups that were manipulated with an error management

culture manipulation based on error management training instructions were explicitly encouraged to explore the task, make errors, and learn from them as a group.

The groups in our study were assigned to one of three experimental conditions: (1) Error management culture manipulation based on error training instructions, (2) Error management culture manipulation based on normative social influence, or (3) Error prevention culture. The groups had to work on creative problem-solving tasks, namely, the marshmallow challenge and a marble run task. In the first task, the groups' goal was to build the highest standing structure from spaghetti with a marshmallow on top. In the second task, the groups had to build the highest functioning marble run, to use as many pieces as possible to build the marble run, and to create a route in which the marble runs as long as possible. We chose these tasks because, among others, team performance can be measured meaningfully and objectively, they entail certain degrees of freedom with regard to how to arrive at a solution, and participants can clearly see and know when they made an error.

We were able to successfully manipulate teams' perception of error management culture in the first task with an error management culture manipulation based on error training instructions. Furthermore, we were able to replicate the beneficial effect of error management culture on performance found in previous field studies. However, the results persisted over time (that is, for a second team task) only when culture strength (i.e., agreement about culture between group members) was high (Schneider, Salvaggio, & Subirats, 2002). Our results not only contribute to the theoretical understanding of error management culture but are also relevant for practitioners in order to gain insights on how an error management culture can be established.

The last chapter (Chapter 5) summarizes the main results of the empirical studies presented in Chapters 2 to 4 and provides a general discussion of the present research, theoretical and practical implications, and also suggests ideas for future research.

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Part II

Empirical Studies

2

Are all Errors Created Equal? Testing the Effect of Error Characteristics on Learning from Errors

Abstract

Individuals and organizations can learn from errors. However, little is known which error characteristics make learning from errors more or less likely. We argue that otherwise identical errors lead to more learning if consequences associated with the error are severe rather than mild and when the error was made by oneself as opposed to by someone else. We experimentally tested our assumptions by prompting participants to react to error scenarios that reflect situations typical for employees at work (Study 1, $N = 121$ from Germany; Study 2, $N = 118$ from the United States). As expected, severity of error consequences increased learning from errors both in terms of affective error learning

The research presented in this dissertation was supervised and supported by Nina Keith and Michael Frese.

Parts of this chapter are currently submitted for publication:

Horvath, D., Klamar, A., Keith, N., & Frese, M. (2019). *Are all errors created equal? Testing the effect of error characteristics on learning from errors in three countries*. Manuscript submitted for publication.

Keith, N., Horvath, D., & Klamar, A. (2019). *The more severe the merrier: severity of error consequences stimulates learning from error*. Manuscript submitted for publication.

Parts of this chapter were presented at the 33rd Annual Conference of the Society for Industrial and Organizational Psychology in Chicago, IL, and at the 19th European Association of Work and Organizational Psychology (EAWOP) Congress in Turin, Italy.

and cognitive error learning (Study 1 and 2). Learning from errors also depended on the agent (i.e., the person who makes the error) (Study 2): people learned more from an error if they were the ones who made the error (as opposed to someone else). The present research experimentally confirms and extends previous correlational studies and highlights the importance of investigating error characteristics.

The topic of learning from errors at work is increasingly gaining attention in applied psychology and management research. Errors are a rich source of information, as they unveil that something went wrong. Scholars agree that errors can foster learning (e.g., Dormann & Frese, 1994; Edmondson, 1996; Ellis, Carette, Anseel, & Lievens, 2014; Frese & Keith, 2015; Heimbeck, Frese, Sonnentag, & Keith, 2003; Ivancic & Hesketh, 1995/1996; Keith & Frese, 2008; Madsen & Desai, 2010; Zakay, Ellis, & Shevsky, 2004). It also seems intuitive that errors vary in the amount of learning they foster (Sitkin, 1992; Cannon & Edmondson, 2005). However, research is scarce on error characteristics that influence learning from errors. Understanding the error characteristics that influence learning from errors enables taking advantage of errors.

In the present research, we systematically test the effects of error characteristics that influence learning from errors by means of vignette experiments. We investigate two error characteristics, namely (a) severity of error consequences (mild vs. severe) (Study 1 and 2) and (b) agent (i.e., the person who makes the error; error made by oneself vs. error made by someone else) (Study 2). More specifically, we propose that (a) severe error consequences lead to more learning than mild consequences and that (b) people learn more from an error if they are the ones who made the error (as opposed to someone else).

With our studies, we aim to contribute to existing literature in the following ways. First,

research is scarce on error characteristics that may affect the amount of learning from errors. Our studies shall add to the relatively small body of research regarding error characteristics and their relation to learning (Homsma, van Dyck, De Gilder, Koopman, & Elfring, 2009; Zakay et al., 2004). Second, previous studies in this area were mostly field studies (Homsma et al., 2009; Madsen & Desai, 2010). While field studies have the advantage of high ecological validity, higher ecological validity can come at the expense of lower internal validity. In organizations, several confounding attributes may affect learning from errors, which leaves the question of causality unanswered (Shadish, Cook, & Campbell, 2002; Frese & Keith, 2015). By investigating learning from errors under standardized experimental conditions, it is possible to account for confounding attributes. In the following section, we define relevant concepts and develop our hypotheses in more detail.

Theory and Hypotheses

Errors and Learning from Errors

Definitions. *Errors* are unintentional deviations from a goal, rule, or standard (Frese & Keith, 2015; Frese & Zapf, 1994; Hofmann & Frese, 2011; Reason, Manstead, Stradling, Baxter, & Campbell, 1990). For example, when an employee makes a planning mistake in a budget plan or a time schedule, s/he made an error. Errors can be distinguished from *violations*. A violation is an intentional deviation from a norm or goal (Frese & Keith, 2015). It has to be noted that errors do not inevitably lead to negative error consequences (Frese & Keith, 2015). Errors can even lead to positive consequences, such as learning (e.g., always double-checking the calculations).

Learning from errors. Learning can be defined as “changes in the knowledge, skills, or attitudes” (Kraiger, Passmore, dos Santos, & Malvezzi, 2015, p. 4) and behavior (Bell, Tannenbaum, Ford, Noe, & Kraiger, 2017; Baldwin & Ford, 1988). How much learning from errors occurs may depend on the amount of attention an error receives. Errors signify that

something is wrong (Sitkin, 1992), and that some (re)action is required. In most cases, errors occur unexpectedly – errors are “negative surprises” (Cannon & Edmondson, 2005, p. 300) that catch attention. The amount of attention devoted to errors may evoke a deeper cognitive processing of the errors. Thereby, errors foster learning. Different error characteristics may determine the amount of attention a person devotes to an error, and thus the amount of learning from errors that can occur. Severity of error consequences and the agent of the error are two such error characteristics.

It has to be noted that learning from errors does not only encompass avoiding the same, specific error in the future (Frese & Keith, 2015). Learning from errors can be conceptualized in different ways. Learning does not necessarily require a change in behaviors (Argote & Miron-Spektor, 2011). A review over the evolution of training and development research and how learning has been conceptualized in the *Journal of Applied Psychology* over the past 100 years (Bell et al., 2017) has identified affective, cognitive, and skill (behavioral) outcomes of learning (Kraiger, Ford, & Salas, 1993). Affective outcomes may include increased motivation or changes in attitudes. Cognitive outcomes may include acquired knowledge, such as the ease of retrieval in terms of memorizing and recollecting knowledge (Metcalf, 2017). Skill outcomes may include mastery of tasks (Bell et al., 2017). As we will describe in more detail, the present research focused on affective error learning in terms of attitudes towards errors and cognitive error learning in terms of recall of error situations.

In the following, we will develop hypotheses on how error characteristics may affect these learning outcomes. In particular, we focus on two error characteristics, namely severity of error consequences and the agent who made the error. We acknowledge that other error characteristics may also be important for learning from errors. We, however, chose to focus in particular on these two error characteristics for the following reasons. 1) We chose to focus on severity of error consequences for two reasons. First, error management theory (Frese & Keith,

2015; Hofmann & Frese, 2011) disentangles errors from their potential consequences. If severity of error consequences would indeed affect learning in our study, this would clearly underline the importance of this theoretical distinction. Second, although severity of error consequences has been explicitly considered in previous research (e.g., Homsma et al., 2009; Zakay et al., 2004), most studies regarding severity of error consequences were field studies. Furthermore, there is a controversial debate on whether more learning occurs from errors with severe or mild consequences (e.g., Sitkin, 1992; Zakay et al., 2004). In sum, more systematic research is needed regarding severity of error consequences. By experimentally investigating the effect of severity of error consequences on learning from errors, we seek to provide more systematic research. 2) We chose to focus on agent (who made the error) for the following reason. Both theory (Bandura, 1986) and empirical evidence regarding learning from similar firms' failures (Kim & Miner, 2007) suggest that learning from others' errors is possible. Still, the error characteristic agent (who made the error) has not been explicitly considered in previous research, nor has it been experimentally tested. If severity of error consequences and agent would indeed affect learning from errors in our study, that would have important practical implications in terms of maximizing learning from errors in organizations. In the following, we will develop our hypotheses in more detail.

Error Characteristics that Influence Learning from Errors

Severity of error consequences. Learning from errors may depend on the severity of error consequences. The debate on whether more learning occurs from errors with severe or mild consequences is controversial. One line of research argues that more learning occurs from errors with mild or moderate consequences (e.g., Sitkin, 1992; Hayward, 2002; Khanna, Guler, & Nerkar, 2016). This follows the proposition that while error consequences need to be severe enough to attract attention (e.g., Homsma et al., 2009; Madsen & Desai, 2010), severe error consequences may pose a threat to humans. The perceived threat may lead to defensiveness

and denial, which impedes learning. This line of argumentation received some supportive and some less supportive results (Hayward, 2002; Homsma et al., 2009; Khanna et al., 2016; Madsen & Desai, 2010; Zakay et al., 2004). The other line of research argues that more learning occurs from errors with severe consequences. In general, humans devote more attention to negative than to positive information (Vaish, Grossman, & Woodward, 2008; Zakay et al., 2004). Errors with mild consequences are considered of less importance (Cannon & Edmondson, 2005). Errors with mild consequences may be more easily overlooked or ignored (Baumard & Starbuck, 2005). Thus, the learning potential of errors with mild consequences cannot fully be used. We follow the second line of argumentation that severe error consequences foster learning. Thus, we propose:

Hypothesis 1: Severity of error consequences increases learning from errors; the more severe the consequences, the more learning from errors will occur.

Agent of the error. *Who* made the error can also influence learning from error. *Who* made the error may influence the attention given to an error, and thus how much learning occurs: people may learn more from errors made by themselves as opposed to errors made by someone else. An error that was made by oneself should have high personal relevance, which attracts a higher degree of attention (e.g., Petty, Cacioppo, & Goldman, 1981). The amount of learning that can occur may thus be the highest when an error was made by oneself. Nevertheless, learning is likely to occur also from errors made by others. According to social learning theory (Bandura, 1986), people also learn from observing others. However, errors made by others may not necessarily be considered personally relevant, as the errors may be attributed to the other person's incompetence or negligence (Frese & Keith, 2015). Consequently, errors made by others may receive less attention and be more easily overlooked or ignored than errors made by oneself. In turn, learning is less likely to occur. We thus assume less learning to occur from errors made by someone else than from errors made by oneself:

Hypothesis 2: Learning from errors depends on the agent (i.e., the person who made the error): More learning from errors occurs when the error is made by oneself as opposed to by someone else.

Overview of Studies

We tested our two hypotheses, namely, the effect of severity of error consequences and agent on learning from errors, in two experiments. In Study 1, we tested the effect of severity of error consequences. In Study 2, we tested the effect of severity of error consequences and agent on learning from errors. Both experiments used vignette methodology. Our two studies differed with regard to the participant samples. Study 1 was conducted in Germany and Study 2 in the United States.

Study 1

Method

Sample. Participants of Study 1 were 121 work-experienced adults ($M = 15.67$ years of work experience, $SD = 13.87$) from Germany.¹ The majority (81.8 %) were currently employed (full-time or part-time) at various organizations, with some of them (19 %) holding a leadership position; 7.4 % were full-time students with work experience; the remaining participants were currently on parental leave, job seeking, or retired (10.8 %). Mean age was 36.92 years ($SD = 15.09$) and 61.2 % were female. Participants were recruited via social media and social networks as well as on campus of a mid-sized German university. Participation was compensated with 8 Euros (approx. 9.5 US\$) or partial course credit.

¹ Of the 122 participants originally recruited, one did not complete the experiment in one session but dispersed completion over several days. We excluded this participant's data from further analyses.

Experimental design and procedure. We used an experimental vignette methodology in a within-participants design with severity of error consequences (mild vs. severe) as experimental factor.

Participants read six scenarios in which we described error situations that varied with regard to severity of error consequences (implemented by three vignettes per level). To avoid sequence, practice, and boredom effects, we counterbalanced the order of presentation and scenario-factor combinations (Girden, 1992). Participants were randomly assigned to one of two permutations of material versions. For later statistical analyses, we used material version as control variable.

In the online experiment, participants were first welcomed and briefly introduced to the study's purpose and procedure. Participants then filled out a questionnaire on demographics. Subsequently, participants were presented with the first experimentally manipulated error scenario. Participants were asked to read the error scenario carefully and to imagine themselves in the described situation. Subsequently, items were presented that constituted the manipulation checks and the first dependent variable (affective error learning). This procedure was repeated for each successive error scenario. Participants then worked on a filler task that lasted about 30 minutes. Afterwards, participants were asked to recall as many of the previously presented error scenarios (cognitive error learning) in as much detail as possible (this constituted our second dependent variable). Up to this point, participants had been unaware that they will be asked to recall the scenarios. Participants then completed a questionnaire on error management culture in their respective organization. Finally, participants were thanked, debriefed, and compensated.

Experimental material. The vignettes (i.e., error scenarios) described typical errors at work (for a sample vignette, see Appendix A). The vignettes were developed based on actual errors as reported by managers in interviews unrelated to the present studies (the interviews

were about errors and error management in organizations). All scenarios were developed and pilot tested with the two goals to arrive at (a) a scenario as realistic as possible and (b) at a distinction as clear as possible between degrees of the experimental factor severity of error consequences (i.e., mild or severe). The manipulation of the experimental factor severity of error consequences was implemented by systematically varying the endings of error scenarios. More specifically, the baseline vignette that described the error and the situation in which the error occurred was identical across experimental conditions, but the consequences that developed from the same error varied. For example, one scenario described an employee having placed a wrong order of materials based on an outdated project plan. In the condition representing mild error consequences, the employee is able to return the surplus materials and to be reimbursed. In the condition representing severe error consequences, the supplier does not accept a return of goods. The employee causes a significant economic damage, as the surplus material cannot be used elsewhere in the company.

Measures.

Manipulation checks. After reading the vignettes and before the first dependent variable was assessed, participants responded to manipulation checks that probed whether participants perceived the severity of the error consequences in the intended way. After reading each vignette, participants were asked to indicate how severe they think the situation is and how negatively they evaluate the situation. We asked participants two questions (e.g., “How negative do you evaluate the described situation?”) to which they responded on a 5-point Likert scale. In addition, we asked them to indicate on a 5-point Kunin face scale how they would feel in the described situation (Kunin, 1955). As expected, we found large effects both for the two questions, $F(1,120) = 291.33$, $p < .001$, $\eta_p^2 = .71$, and for the Kunin item, $F(1,120) = 190.01$, $p < .001$, $\eta_p^2 = .61$, indicating that participants perceived the severity of error consequences in the intended way.

Dependent variables. Following the multidimensionality perspective on learning (e.g., Bell et al., 2017; Kraiger et al., 1993), we address two aspects by which learning can be conceptualized: we assessed affective error learning by using a self-report measure, and cognitive error learning in terms of recall of error situations. We assessed *affective error learning* with 3 of the 4 items of the subscale “learning from errors” of the Error Orientation Questionnaire (EOQ; Rybowskiak, Garst, Frese, & Batinic, 1999)². The EOQ is designed to measure “attitudes to and coping with errors at work” (Rybowskiak et al., 1999, p. 527) of individuals or groups. We slightly modified item wordings to fit the presently used vignettes. For example, the original item “My mistakes help me to improve my work” was changed to “This mistake helps me to improve my work”. Participants responded on a 5-point Likert scale. In the present study, median Cronbach's alpha was .88 across experimental conditions. For *cognitive error learning* (i.e., *recall of error situations*)³, participants were asked to recall as many of the previously presented error scenarios in as much detail as possible. In order to facilitate recall, we asked for the error situation, as well as the error consequences. Two raters independently assigned the values 0 (incorrect), 1 (partially correct), or 2 (fully correct) to the recall of the error situation and to the error consequences, respectively, resulting in a maximum score of 4. Inter-rater agreement was high, with a median ICC(3,2) of .99 (range .96 to .99) across the scenarios.

Filler task (cognitive ability test). As filler task (after presentation of error scenarios and before recall of error scenarios), we used a freely available German cognitive ability test (Satow, 2017) that measures numerical skills (22 items; Cronbach's alpha = .70) and spatial-

² We did not include the fourth item of the scale “Mistakes provide useful information for me to carry out my work” in our study. In the German version of the scale, this item includes a hypothetical construction or “if clause” (“If an error happens to me...”). We found this item to be too complex and unsuitable for our purposes, and barely equivalent to the English translation. In order to minimize differences in different language versions of the questionnaire, we decided not to include this item in our study.

³ Originally, we had planned to additionally include multiple-choice test items, but the items were too easy (75 to 90 % correct answers across conditions) and produced ceiling effects.

visual skills (12 items; Cronbach's alpha = .38) (overall Cronbach's alpha = .67). Our primary goal was to use this test as a filler task, as it is common to use unrelated filler tasks in experiments that use recall tests. Our second goal was to use it as a potential control variable for the recall task because we suspected that performance on this cognitive measure may be influenced by participants' cognitive abilities⁴.

Results and Discussion

Means, standard deviations, and correlations of Study 1 variables are depicted in Table 2.1.

⁴ We reran all analyses with cognitive abilities included as a covariate, but the pattern and magnitude of effects were unaltered.

Table 2.1
Means, Standard Deviations, and Intercorrelations of Study Variables in Study 1

	<i>M</i>	<i>SD</i>	1	2	3	4	5	6	7	8	9
Person characteristics											
1. Age	36.92	15.09	—								
2. Gender	—	—	-.12	—							
3. Cognitive ability (filler task)	25.43	6.13	-.12	-.05	(.67)						
Dependent variable affective error learning (overall and by levels of severity of error consequences)											
4. Overall (aggregated across levels)	4.11	0.63	.24**	.17	.04	(.93)					
5. Mild error consequences	4.05	0.69	.21*	.17	.05	.91**	(.92)				
6. Severe error consequences	4.17	0.69	.23*	.14	.03	.91**	.66**	(.91)			
Dependent variable cognitive error learning (overall and by levels of severity of error consequences)											
7. Overall (aggregated across levels)	1.40	0.94	-.14	.01	.37**	-.16	-.14	-.14	(.99)		
8. Mild error consequences	1.23	1.04	-.14	.06	.30**	-.13	-.11	-.13	.82**	—	
9. Severe error consequences	1.57	1.19	-.09	-.04	.33**	-.13	-.13	-.11	.86**	.42**	—

Note. $N = 121$. Cronbach's alpha coefficients are shown in parentheses along the diagonal. For the variable "cognitive error learning" median ICC (inter-rater agreement) is shown in parentheses along the diagonal. Gender was coded 0 for male and 1 for female.

* $p < .05$. ** $p < .01$.

Main effect of severity of error consequences. Hypothesis 1 predicted a main effect of severity of error consequences on learning from errors in that learning is higher for errors with severe consequences. We first tested this hypothesis simultaneously for both the affective and cognitive dependent variables, using repeated measures MANOVA. In support of Hypothesis 1, severity of error consequences had a main effect on learning from errors in that more learning occurred from errors with severe than with mild consequences, $F(2,118) = 7.74$, $p < .001$, $\eta_p^2 = .12$. As indicated by additional post-hoc univariate analyses, this effect held for both dependent variables, $F(1,119) = 5.34$, $p < .05$, $\eta_p^2 = .04$, and $F(1,119) = 10.37$, $p < .01$, $\eta_p^2 = .08$ for affective and cognitive learning from errors, respectively (see Figure 2.1, Panels a and b)⁵.

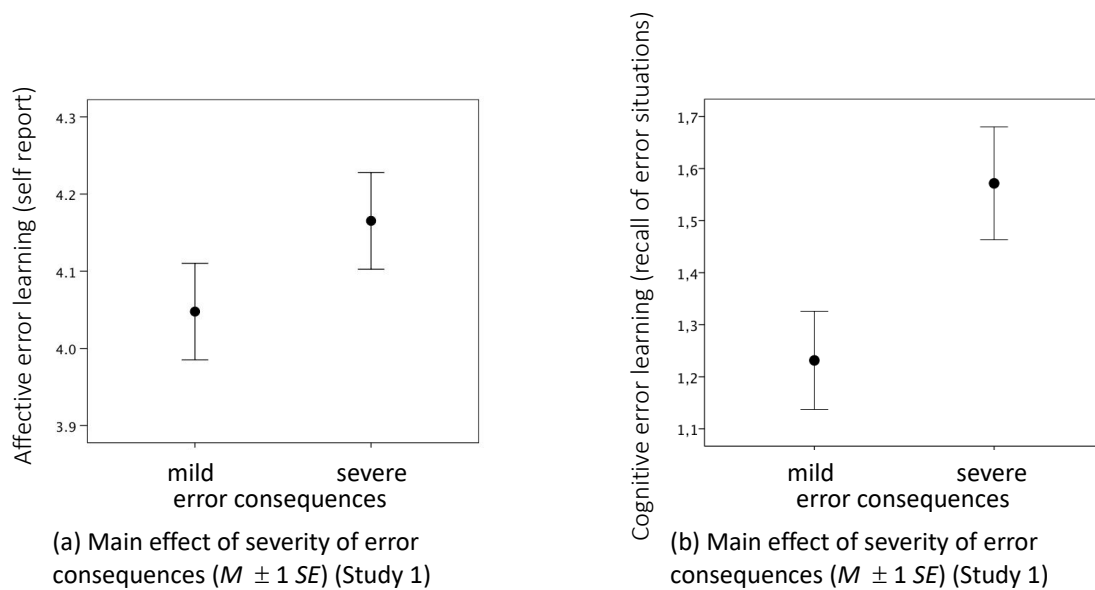


Figure 2.1. Main effect of severity of error consequences on affective error learning (Panel a) and cognitive error learning (Panel b) in Study 1.

⁵ The other effects in the ANCOVAs (not pertinent to the hypothesis) were as follows. For the affective learning measure: no main effect of material version, $F(1,119) = 0.08$, $p = .77$, $\eta_p^2 = .00$, no interaction effect of material version with severity of error consequences, $F(1,119) = 2.22$, $p = .14$, $\eta_p^2 = .02$. For the cognitive learning measure (recall of error situations): no main effect of material version, $F(1,119) = 1.50$, $p = .22$, $\eta_p^2 = .01$, interaction effect of material version with severity of error consequences, $F(1,119) = 9.40$, $p < .01$, $\eta_p^2 = .07$, indicating that the hypothesized effect of the independent variable was present on average but differed in magnitude across material versions. Such interaction effects are common in experiments that include multiple naturalistic materials and they underscore the appropriateness of systematically varying and statistically controlling for experimental material.

In sum, the results of Study 1 are in line with our propositions concerning the role of severity of error consequences for learning from errors. With Study 2, we sought to replicate our findings in a different sample (sample from the United States), and to extend them by investigating the role of a second error characteristic for learning from errors: agent (i.e., the person who made the error).

Study 2

Method

Sample. Participants were 118 working adults from the United States, recruited via eLancing websites⁶. Research has demonstrated that data gathered via eLancing websites are of satisfactory quality (e.g., Buhrmester, Kwang, & Gosling, 2011). The quality can be augmented by taking certain steps, such as using attention check items and fair compensation of the participants (e.g., Aguinis & Lawal, 2012; Cheung, Burns, Sinclair, & Sliter, 2017). We carefully followed these recommendations. Mean age of our participants was 35.76 years ($SD = 10.54$) and 35 % were female. Participants' average work-experience was 14.31 years ($SD = 10.48$) and 39 % reported to hold a leadership position. Participants came from different industries, the most frequent were Information and Communication (14.4 %), Manufacturing (12.7 %) and Financial and Insurance activities (12.7 %). Participants received USD 4.50 for participation (which corresponds to an hourly wage of approximately USD 9.00 and was thus in line with the United States federal minimum wage). The criteria for inclusion of respondents in the survey were age (>18 years), place of residence (the United States), and employment status (at least part-time employed).

Experimental design and procedure. Design and procedure of Study 2 were similar to those of Study 1, with the following differences. First, in Study 2 we tested two experimental

⁶ Of the 120 participants originally recruited, two participants had to be excluded from further analyses.

factors: severity of error consequences (mild vs. severe) and agent (self vs. other, e.g., a close colleague), resulting in a 2x2 within-participants design. Second, participants read not six but eight scenarios in which we described error situations that varied with regard to severity of error consequences and agent. As in Study 1, to avoid sequence, practice, and boredom effects, we counterbalanced the order of presentation and scenario-factor combinations (Girden, 1992). Participants were randomly assigned to one of four permutations of material versions. For later statistical analyses, we used material version as control variable. Third, as a filler task, we only used the subscale measuring numerical skills of the cognitive ability test applied in Study 1.

Experimental material. In Study 2, we used the same six vignettes (i.e., error scenarios) as in Study 1 that described typical error situations at work. We additionally included two new vignettes. As in Study 1, the two new vignettes were pilot tested to arrive at (a) a scenario as realistic as possible and (b) at a distinction as clear as possible between degrees of the experimental factor severity of error consequences (i.e., mild or severe). As in Study 1, the manipulation of the experimental factor severity of error consequences was implemented by systematically varying the endings of error scenarios. The manipulation of the experimental factor agent was implemented by varying the person who made the error (self or colleague), for example “you made the mistake to use the wrong, out-dated project plan as a basis for ordering” vs. “your colleague made the mistake to use the wrong, out-dated project plan as a basis for ordering”.

Measures.

Manipulation checks. We used the same manipulation checks as in Study 1. Again, we found large effects both for the two questions, $F(1,117) = 297.96, p < .001, \eta_p^2 = .72$, and for the Kunin item, $F(1,117) = 276.19, p < .001, \eta_p^2 = .70$, indicating that our manipulations had worked well.

Dependent variables. As in Study 1, we assessed *affective error learning* with 3 of the 4 items of the subscale “learning from errors” of the Error Orientation Questionnaire (EOQ; Rybowskiak et al., 1999). Median Cronbach's alpha was .91 across experimental conditions. For *cognitive error learning* (i.e., *recall of error situations*), participants were asked to recall as many of the previously presented error scenarios in as much detail as possible. In order to facilitate recall, we asked for the agent who made the error, the error situation, as well as the error consequences. Two raters independently assigned the values 0 (incorrect), 1 (partially correct), or 2 (fully correct) to the recall of the error situation and to the error consequences, respectively. Additionally, the two raters coded whether participants correctly recalled the agent who made the error with 0 (incorrect) or 1 (correct), resulting in a maximum score of 5. Inter-rater agreement was high, with a median ICC(3,2) of .99 (range .95 to 1.00) across the scenarios.

Filler task (cognitive ability test). As filler task (after presentation of error scenarios and before the recall of error scenarios), we used the same measure for numerical skills of the freely available cognitive ability test (Satow, 2017) that we also used in Study 1 (22 items; Cronbach's alpha = .86).

Results

Means, standard deviations, and correlations of variables used in Study 2 are depicted in Table 2.2.

Table 2.2
Means, Standard Deviations, and Intercorrelations of Study Variables in Study 2

	<i>M</i>	<i>SD</i>	1	2	3	4	5	6	7	8	9	10	11	12	13
Person characteristics															
1. Age	35.76	10.54	-												
2. Gender	1.35	0.48	.33**	-											
3. Cognitive ability (filler task)	15.44	4.34	.09	.00	(.86)										
Dependent variable affective error learning (overall and by levels of severity of error consequences and agent)															
4. Overall (aggregated across levels)	4.11	0.57	.16	.23*	.01	(.91)									
5. Mild error consequences	4.04	0.66	.17	.16	.03	.92**	(.91)								
6. Severe error consequences	4.19	0.60	.12	.25**	-.01	.90**	.65**	(.86)							
7. Self	4.31	0.56	.21*	.23*	.13	.84**	.76**	.77**	(.83)						
8. Other	3.91	0.74	.09	.18*	-.08	.91**	.85**	.81**	.55**	(.93)					
Dependent variable cognitive error learning (overall and by levels of severity of error consequences and agent)															
9. Overall (aggregated across levels)	1.74	0.95	.13	-.08	.31**	.19*	.20*	.14	.26**	.09	(.99)				
10. Mild error consequences	1.62	1.11	.13	-.09	.29**	.16	.19*	.10	.19*	.10	.85**	-			
11. Severe error consequences	1.86	1.12	.10	-.05	.23*	.16	.15	.15	.26**	.06	.85**	.45**	-		
12. Self	1.73	1.19	.08	-.11	.24**	.11	.12	.08	.23*	-.01	.82**	.64**	.76**	-	
13. Other	1.74	1.14	.14	-.02	.25**	.20*	.20*	.16	.19*	.16	.81**	.75**	.63**	.33**	-

Note. $N = 118$. Cronbach's alpha coefficients are shown in parentheses along the diagonal. For the variable "cognitive error learning" median ICC (inter-rater agreement) is shown in parentheses along the diagonal. Gender was coded 0 for male and 1 for female.

* $p < .05$. ** $p < .01$.

Descriptive analyses showed that our two learning measures, affective error learning and cognitive error learning, were correlated by $r = .19$ ($p < .05$) (note that in Study 1, we did not find a significant correlation between our two learning measures). This significant, but small correlation indicates that our two variables measure the same construct, namely learning from errors, but cover somewhat different aspects of the criterion space. Furthermore, as we expected, cognitive ability was positively related to cognitive error learning, but not related to affective error learning, indicating that our two dependent variables differ in the extent of cognitive loading. Hence, we included cognitive ability as a between-participants covariate and reran all analyses, but the pattern and magnitude of effects were unaltered. In the following, we therefore report results without this additional covariate.

Severity of error consequences and agent. Hypothesis 1 predicted that severity of error consequences increases learning from errors in that learning is higher for errors with severe consequences. Hypothesis 2 predicted that learning from errors depends on the agent in that learning is higher when the error is made by oneself as opposed to when the error is made by someone else. The hypothesized effects were tested simultaneously in a repeated-measures MANOVA with the two learning measures affective error learning and cognitive error learning as dependent variables. We included material version (i.e., vignette-factor combination) as a between-participants control factor (Judd, Kenny, & McClelland, 2001).

As we expected, the multivariate test results showed a main effect of severity of error consequences on learning from errors, $F(2,113) = 7.88$, $p < .001$, $\eta_p^2 = .12$, and a main effect of agent, $F(2,113) = 23.07$, $p < .001$, $\eta_p^2 = .29$. Thus, all two hypotheses were supported.

Additional, post-hoc univariate analyses showed the expected main effect of severity of error consequences for both learning measures, for affective error learning, $F(1,114) = 10.51$, $p < .01$, $\eta_p^2 = .08$, and for cognitive error learning, $F(1,114) = 6.20$, $p < .05$, $\eta_p^2 = .05$ (see Figure 2.2 Panel a and b). Regarding the agent, we found the expected main effect for

affective error learning, $F(1,114) = 44.18, p < .001, \eta_p^2 = .28$ (see Figure 2.2, Panel c), but not for cognitive error learning, $F(1,114) = 0.15, p = .70, \eta_p^2 = .00$.⁷

In sum, Study 2 replicated the results of Study 1 with regard to the main effect of severity of error consequences on learning from errors and extended them with regard to the main effect of agent. Not only did participants report more learning after errors with severe consequences (affective learning measure); they also recalled error scenarios with severe consequences better than error scenarios with mild consequences (cognitive learning measure). Participants also reported more learning if the error was made by oneself than made by a close colleague. However, participants did not recall error scenarios where the agent was oneself better than error scenarios where the agent was a close colleague.

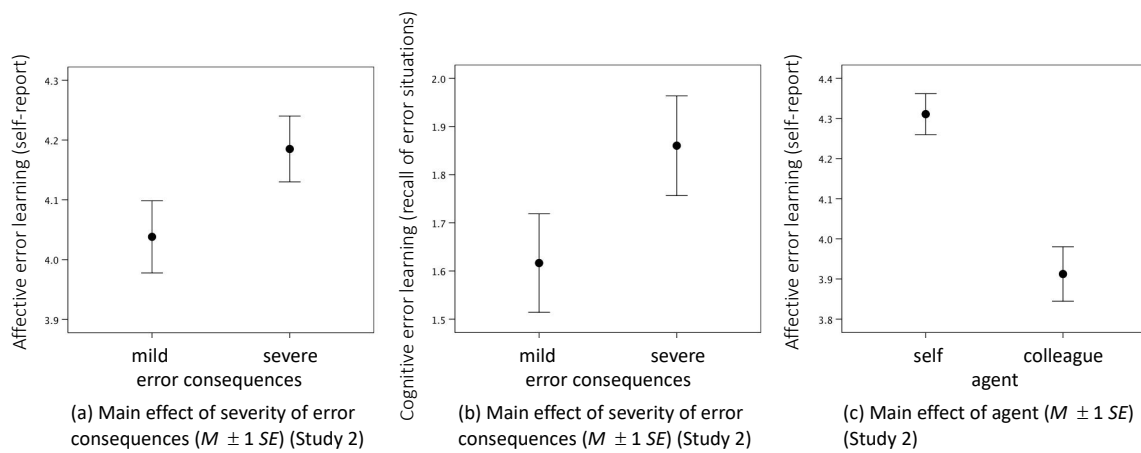


Figure 2.2. Main effect of severity of error consequences on affective error learning (Panel a) and cognitive error learning (Panel b), and main effect of agent on affective error learning (Panel c) in Study 2.

⁷ The other effects in the repeated measures MANOVA (not pertinent to the hypothesis) were as follows. For the first learning measure (affective error learning): no main effect of material version, $F(3,114) = 1.05, p = .38, \eta_p^2 = .03$, no interaction effect of material version with severity of error consequences, $F(3,114) = 2.15, p = .10, \eta_p^2 = .05$, or agent, $F(3,114) = 1.13, p = .34, \eta_p^2 = .03$. For the second learning measure (cognitive error learning): no main effect of material version, $F(3,114) = 0.21, p = .89, \eta_p^2 = .01$, but an interaction effect of material version with severity of error consequences, $F(3,114) = 15.95, p < .001, \eta_p^2 = .30$, and agent, $F(3,113) = 3.40, p < .05, \eta_p^2 = .08$.

Discussion

It is well-established that individuals can learn from errors (e.g., Frese & Keith, 2015). However, we know surprisingly little whether and how errors differ in the extent to which they foster learning. In the present research, we demonstrated in two samples that otherwise identical errors differ in the extent to which they stimulate learning, dependent on error characteristics such as severity of error consequences or the agent who made the error. More specifically, in two vignette experiments, we demonstrated that learning was more likely when (a) the consequences of the errors were severe as opposed to mild and when (b) the error was made by oneself as opposed to by someone else.

Theoretical Contributions

First, we were able to demonstrate that the amount of learning from errors that occurred depended on the severity of the error consequences: as predicted, more learning occurred from errors with severe as opposed to mild consequences. This is interesting, as the vignette methodology allowed us to hold the error itself and the context in which it occurred constant. We suggest that both on the individual and organizational level, the process that explains why more learning occurs from errors and incidents with severe consequences is that errors with severe consequences attract more attention. This is in line with Cannon and Edmondson (2005), who argue that errors with mild consequences are more easily overlooked or ignored, and thus receive less attention. It is striking that slight modifications of our vignettes (e.g., replacing mild with severe consequences) resulted in such strong effects, although participants responded to otherwise identical error scenarios with identical lessons to be learned.

One potential alternative explanation for our result that more learning occurred from errors with severe consequences is that the mechanism behind the effect is not the severity but the noticeability of errors with severe consequences. However, this explanation would not contradict our argumentation: We argue that errors with severe consequences foster learning

because they attract more attention – they are more noticeable. In order to better understand which aspects of severity foster learning, future studies may systematically vary different aspects of severity. For example, aspects of severity may be who is affected by the error, how many people are affected by it, or how big the damage is that is caused by the error.

Second, we were able to demonstrate that *who* made the error determined the amount of learning from errors that occurred: we observed more affective error learning from errors made by oneself as opposed to by someone else. While learning can occur from observing others (e.g., Bandura, 1986), we assumed that errors made by oneself are considered of higher personal relevance, which increases learning potential. This is in line with our results regarding affective error learning but not regarding cognitive error learning. We did not find differences in cognitive learning from errors made by oneself as opposed to by someone else. There are three possible explanations for our results that participants reported more affective learning from errors made by oneself but not did not recall more error situations with errors made by oneself. First, as Bandura (1986) argued, learning can occur while observing others. It is possible that despite reporting more learning from errors made by oneself people learn just as well from errors made by others. Second, it is possible that the effect of severity of error consequences was superior over the effect of agent. Participants thus were able to remember whether the error's consequence was severe or mild but could not remember anymore who made the error. Personal relevance (i.e., the error was made by oneself) may be important in the situation when the error happens. This is in line with our result that participants reported more learning from errors made by oneself after reading the vignettes. Later on, however, it may be the consequence of the error that really matters. Third, there is a “general tendency to overestimate the importance of personal or dispositional factor relative to environmental influences” (i.e., fundamental attribution error; Ross, 1977): People tend to attribute dispositional factors to other people's behavior in a given situation and underemphasize

situational factors. This may also be the case when observing others while doing an error. Thinking that the error was the result of the person's fault could result in reporting less learning afterwards. The effect of the fundamental attribution error, however, may decrease over time and people still remember and learn from the error made by the other person.

Strengths, Limitations, and Directions for Future Research

In the present study, we used vignette experiments to test our assumptions that severity of error consequences and the person who made the error influence learning from errors. Learning from errors is a critical topic that may be difficult to study in non-experimental field settings for the following reasons. First, while errors happen quite often (e.g., Frese, 1991), many people are reluctant to report errors. This may be because in many companies, errors are stigmatized so that employees might fear negative consequences when reporting errors. Second, in natural field settings, it is hardly possible to isolate error characteristics in a similar manner as we did in our study. While conducting a study in natural field settings as opposed to employing a vignette methodology would produce findings of high ecological validity, it would be difficult to clearly identify which error characteristics influenced learning – which was the aim of the present study. In that way, we were able to hold all error characteristics except for our independent variables constant.

In regard to ecological validity, we see the prior concern of our study in the way we assessed learning from errors. We assessed affective error learning using three self-report items of the “learning from errors” subscale of the Error Orientation Questionnaire (Rybowiak et al., 1999). As a self-report measure, responses on our affective error learning scale may be affected by response biases. Participants may have indicated more affective error learning than we may observe using a different way of assessment. In order to address this issue, we additionally assessed cognitive error learning in terms of recall of error situations by asking participants to describe the error situation and the error consequences we had previously presented to them.

Even though we cannot be sure that the pattern we found in our results will also be reflected in actual behavior, we propose that our measures are valid proxies for actual learning from errors for mainly four reasons. First, our affective error learning measure was a validated measure of learning from errors (Rybowiak et al., 1999). Second, affective learning from errors can be considered as a readiness and intention to learn from that particular error. Social psychological research demonstrates substantial correlations between intentions and behavior (Ajzen & Fishbein, 1977). Third, our findings regarding severity of error consequences are in line with those of previous correlational research using non-experimental field data (Homsma et al., 2009). Fourth, in one of our studies (Study 2), we were able to demonstrate that the cognitive error learning variable correlated with the affective error learning variable. While we acknowledge that recalling error scenarios and actual learning from error are not the same, recalling the error and the consequences caused by the error are necessary prerequisites and intrinsically tied to actual learning from errors.

The aim of our study was to systematically assess how varying the factors agent and severity of error consequences influences learning from errors. We chose an experimental setting to study variations of these factors under standardized conditions – by means of vignette experiments. This allowed us to identify a cause-effect relationship for affective and cognitive error learning. At the same time, it came at the expense of a behavioral learning measure, as it did not allow participants to actually demonstrate what they had learned from the errors. We acknowledge the importance of studying actual behavioral reactions to the errors, and strongly encourage future studies in this area. Future studies on learning from errors may aim at developing a learning measure that on the one hand allows to be employed in standardized settings such as experiments, but on the other hand has higher ecological validity than the measures we employed.

A first step may be to replicate our vignette experiments, but additionally asking

participants to describe what they would have done differently if they were asked to do the same task again. Subsequently, two independent raters may rate participants' answers in terms of the extent of learning from errors. This would allow for a systematic variation of the factors we had investigated, while at the same time giving participants the opportunity to articulate what they had learned. Another possibility may be to invite participants into a laboratory to work on standardized tasks. For standardized tasks, the possible errors participants could make would be limited to a certain pool of errors. These errors may be categorized and the learning that results from them could be assessed. One way of assessing actual learning from these errors may be to see whether participants repeated the errors they had made. Another possible future study may be a field study in one specific department of an organization, which may be considered as a balance between a standardized setting, while at the same time allowing to observe behavioral outcomes in reaction to errors. It has to be noted, however, that not all errors must lead to behavioral outcomes, or that the time lag between the error and the adapted behavior may be too long to observe it during a field study.

Furthermore, future studies could also explore additional error characteristics such as the level of action regulation (Frese & Zapf, 1994; Hacker, 1998; Hofmann & Frese, 2011; Zapf, Brodbeck, Frese, Peters, & Prümper, 1992). The action regulation theory differentiates three levels of action regulation: sensorimotor, routinization, and intellectual. Low-level errors occur while executing routinized or familiar tasks that require little or no conscious control, for example, forgetting to send the attachment of an e-mail. High-level errors, in contrast, occur when executing less routinized and less familiar tasks that require conscious control, for example, making a wrong decision due to inadequate knowledge. We assume that low-level errors lead to less learning as they are less informative than high-level errors.

It is also important to systematically explore cross-cultural influences on learning from errors. Gelfand, Frese, and Salmon (2011) proposed a number of cultural dimensions that might

affect responses to errors and error management in organizations. For example, a low degree of uncertainty avoidance in a culture may lead to less intensive negative emotional reactions to errors.

Practical Implications

All the errors employed in our study, and all error characteristics evoked learning from errors. Consequently, one approach to increase learning from errors, particularly from errors with mild consequences and errors that were made by others, would be to put them in the focus of attention. That way, errors with mild consequences and errors made by others would be more noticeable. This may be of particular importance, as most errors that happen every day are, luckily, errors that do not end in catastrophes – their consequences are mild. In order to fully exploit the learning potential of errors with mild consequences, managers might suggest regular meetings in which particularly such errors are discussed. Discussion of errors with mild consequences might be more open, as fear and negative emotions should be reduced: “nothing happened, anyway, so why not talk about it!”, should be the prevailing attitude instead of “nothing happened anyway, so why bother sharing what went wrong?”. Furthermore, these meetings may tackle the implications of our finding that learning from errors also occurs when someone else has made the error – the communication lets other people know about the error, so the team or the organization as a whole can learn from it. “You don't need to make an error yourself in order to learn from it!”, could be a motto that encourages sharing the error, as one does something that benefits the group as a whole.

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3

Does Country Matter? Testing the Effect of Error Characteristics on Learning from Errors in Three Countries

Abstract

Errors can be a source of learning. However, little is known to what extent learning from errors depends on error characteristics and the context in which the error was made. We tested the assumption that more learning occurs from errors with severe consequences and when the error was made by oneself. We further investigated the role of organizational culture for learning from errors and if and how learning from errors differs between countries. In a vignette study ($N = 588$ from the United States, Hungary, and Germany), participants responded to error scenarios that happen to employees at work. As expected, people learned more from errors in terms of affective error learning if consequences were severe, if the error was made by themselves, and when more error management culture was experienced. Furthermore,

The research presented in this dissertation was supervised and supported by Nina Keith and Michael Frese.

Parts of this chapter are currently submitted for publication:

Horvath, D., Klamar, A., Keith, N., & Frese, N. (2019). *Are all errors created equal? Testing the effect of error characteristics on learning from errors in three countries*. Manuscript submitted for publication.

Parts of this chapter were presented at the 33rd Annual Conference of the Society for Industrial and Organizational Psychology in Chicago, IL.

we found differences between countries in affective learning from errors in that participants from the United States learned more from errors than participants from Hungary or Germany. This relationship was mediated by error management culture. With our study, we aim to contribute to a better exploitation of the learning potential inherent in errors.

In the previous chapter, we demonstrated that the amount of learning from errors depends on (a) the severity of error consequences, and (b) the agent who made the error. As predicted, more learning occurred from errors with severe as opposed to mild consequences and when the error was made by oneself as opposed to by someone else. Our results were consistent in two geographically different samples: Germany and the United States. However, due to differences in our study designs in the two samples, we were not able to test whether there are country differences in learning from errors. In the present chapter, we seek to replicate the pattern of results from our studies in Chapter 2 and to extend them by assessing country differences in learning from errors by collecting data in three different countries, namely the United States, Hungary, and Germany. In particular, we investigate (c) the relationship of organizational error culture (i.e., shared norms and beliefs about errors) and learning from errors, and (d) whether there are country differences in error management culture, and (e) learning from errors. We also explore whether (f) potential country differences in learning from errors may be due to differences in error management culture. For this purpose, we study samples of three different countries, namely the United States, Hungary, and Germany, and assess error management culture. We selected the United States, Hungary, and Germany, as these countries differ in regard to the way people deal with uncertainty (House, Hanges, Javidan, Dorfman, & Gupta, 2004). The way people deal with uncertainty may influence how people consider and deal with occurring errors (i.e., error management culture),

as errors are always, to a certain extent, ambiguous. This, in turn, may influence how much learning from errors occurs.

The question of whether and how countries differ in organizational culture and learning from errors has important implications for both theory and practice. We aim to shed light on why country differences may be observed in learning from errors. From a practical perspective, only by understanding which error characteristics and how the cultural context determine learning from errors can organizations develop appropriate interventions to improve learning from errors. In the following section, we define relevant concepts and develop our hypotheses in more detail.

Recap from the Previous Chapter: Theory and Hypotheses

Errors and Learning from Errors

We define *errors* are unintentional deviations from goals, rules, or standards (Frese & Keith, 2015; Frese & Zapf, 1994; Hofmann & Frese, 2011; Reason, Manstead, Stradling, Baxter, & Campbell, 1990). Errors do not inevitably lead to negative error consequences (Frese & Keith, 2015) and can even lead to positive consequences, such as learning.

We define learning as “changes in the knowledge, skills, or attitudes” (Kraiger, Passmore, dos Santos, & Malvezzi, 2015, p. 4) and behavior (Bell, Tannenbaum, Ford, Noe, & Kraiger, 2017; Baldwin & Ford, 1988). How much learning from errors occurs may depend on the amount of attention an error receives. Different error characteristics may determine the amount of attention a person devotes to an error, and thus the amount of learning from errors that can occur. Severity of error consequences and the agent of the error are two such error characteristics.

Error Characteristics that Influence Learning from Errors

Severity of error consequences. Learning from errors may depend on the severity of

error consequences. We propose that severity of error consequences affects learning from errors positively. Errors may instigate increased attention, and that attention is a prerequisite for learning. As greater attention should be paid to errors with more severe consequences, more learning should follow. Cannon and Edmondson (2005) argue that errors with mild consequences are more easily overlooked or ignored, and are therefore less likely to lead to learning than errors with more severe consequences. This is in line with empirical evidence that suggests that failure, which might be considered as a negative error consequence, leads to more learning than success (e.g., Joung, Hesketh, & Neal, 2006; Madsen & Desai, 2010; Zakay, Ellis, & Shevsky., 2004) and that more learning occurs after errors with more severe rather than mild or moderate consequences (Homsma, van Dyck, De Gilder, Koopman, & Elfring, 2009). Consequently, we hypothesize that learning from errors will increase with the severity of error consequences. Thus, we propose:

Hypothesis 1: Severity of error consequences increases learning from errors; the more severe the consequences, the more learning from errors will occur.

Agent of the error. *Who* made the error can also influence learning from errors. Based on social learning theory (Bandura, 1986), it can be assumed that learning can occur while observing others, thus when someone else makes an error. In an organization, for example, an employee can learn from a colleague's error. However, errors made by others can also be overlooked easily because they might be considered irrelevant or seen as a result of the other person's incompetence and negligence (Frese & Keith, 2015). Furthermore, as people pay greater attention to personally relevant information (e.g., Petty, Cacioppo, & Goldman, 1981), learning from an error should be higher when the agent of the error is oneself. We argue that personal relevance attracts more attention, thus learning should be most likely if oneself makes an error. We propose:

Hypothesis 2: Learning from errors depends on the agent (i.e., the person who made the error): More learning from errors occurs when the error is made by oneself as opposed to by someone else.

Theory and Hypotheses

Cultural Context and Learning from Errors

Learning from errors may also be affected by cultural context. *Culture* consists of values and practices (House et al., 2004; Schein, 2004; Reichers & Schneider, 1990), which can vary between organizations and countries. In the following, we discuss how organizational culture may influence learning from errors and why we expect differences between countries in learning from errors. For organizational culture, we consider organizational practices concerning errors – i.e., an *error management culture* (van Dyck, Frese, Baer, & Sonnentag, 2005). For country differences, we examine the cultural dimension of uncertainty avoidance (House et al., 2004).

Nearly all organizations and countries regard errors as negative events. Errors thus evoke negative reactions such as anxiety, anger, shame, and guilt (Carmeli & Gittell, 2009; Edmondson, 1999; Ivancic & Hesketh, 1995/1996; Keith & Frese, 2005, 2008; Zhao, 2011). Negative reactions may reduce learning. When errors are framed as indicators of failure and lack of competence, they set off “negative self-evaluative reaction cycles” of self-doubt and dissatisfaction (Wood, Kakebeeke, Debowski, & Frese, 2000, p. 267). These may have negative effects on learning. On the contrary, in cultures where errors are considered as chances to learn, i.e., an error management culture, learning should be fostered.

Error management culture and learning from errors. Error management culture entails “practices related to communicating about errors, to sharing error knowledge, to helping in error situations, and to quickly detecting and handling errors” (van Dyck et al., 2005, p.

1229). Error management culture influences whether and how much learning from errors occurs (Keith & Frese, 2011). When the error management culture is high, it is acknowledged that despite best efforts to prevent errors, it is impossible to be completely error free (Reason, 1997). The acknowledgement that errors can happen at all times, and to everyone, leads to a culture in which the occurrence of errors is not a taboo that has to be avoided at all cost – error strain will be low. Consequently, when the error management culture is high, negative emotions are kept at bay (Bell & Kozlowski, 2008; Keith & Frese, 2005). The positive framing of errors may help learners to accept errors. Accepting the occurrence of errors can help controlling negative emotions in response to errors (Heimbeck, Frese, Sonnentag, & Keith, 2003), which benefits learning (van Dyck et al., 2005). A mind-set of acceptance of errors may even increase motivation to learn, as mastery and task interest may be strengthened (Bell & Kozlowski, 2008). We thus predict:

Hypothesis 3: Error management culture is associated with learning from errors, in that learning is higher if more error management culture is experienced.

Country differences in learning from errors. Learning from errors may differ from one country to another. Both theoretical (e.g., Gelfand, Frese, & Salmon, 2011) and empirical evidence (e.g., Davis, Bryant, Tedrow, Liu, Selgrade, & Downey, 2005; Helmreich & Merritt, 1998) suggest that the way people deal with errors varies across countries. Learning from errors may thus differ as well. In the following, we take a closer look at how country differences can be described.

Country differences can be described using cultural dimensions (e.g., Hofstede, 1980; House et al., 2004). We deem the GLOBE (House et al., 2004) dimension of uncertainty avoidance to be particularly important for the way people deal with errors, i.e., error management culture, consequently for learning from errors.

Uncertainty avoidance refers to “the extent to which ambiguous situations are

threatening to individuals, to which rules and order are preferred, and to which uncertainty is tolerated in society” (de Luque & Javidan, 2004, p. 602). In other words, uncertainty avoidance denotes “the extent to which members of collectives seek orderliness, consistency, structure, and formalized procedures, and laws to cover situations in their daily lives” (de Luque & Javidan, 2004, p. 603). For the purpose of our study, we use the GLOBE societal practices scores, because we are interested in actual practices that are typical for a country, rather than in people's attitudes (values) on how things should be in their respective country.¹

The context, such as the location, time or physical environment, in which an organization operates has an impact on organizational behavior, thus on organizational culture (Johns, 2006). Country practices may shape work processes in organizations, as well as the way people in organizations interpret and deal with occurring phenomena (Noort, Reader, Shorrock, & Kirwan, 2016), such as errors. This is in line with the empirical evidence, for example, of GLOBE that suggest societal practices of uncertainty avoidance to affect organizational practices of uncertainty avoidance (de Luque & Javidan, 2004). Noort and colleagues (2016) also found the cultural dimension uncertainty avoidance to be associated with organizational culture, in particular with organizational safety climate (Noort et al., 2016).

We believe that uncertainty avoidance may be particularly important for error management culture, and consequently for learning from errors. Errors and their consequences are, to a certain extent, ambiguous. An error is ambiguous for the following three reasons. First, the error may not be immediately detected. Second, once the error is detected, there can be ambiguity regarding causes of the error: several actions may have caused the error. Third, there

¹ It should be noted that uncertainty avoidance in the GLOBE project and by Hofstede capture different constructs (de Luque & Javidan, 2004; Venaik & Brewer, 2010). According to Venaik and Brewer (2010), uncertainty avoidance by GLOBE is unidimensional and captures the importance of orderliness, consistency, structure, as well as rules and laws. On the contrary, uncertainty avoidance by Hofstede is multifaceted and captures three different aspects: feelings of nervousness and tension, employment stability, and rule orientation. Furthermore, Hofstede's conceptualization of uncertainty avoidance entails mainly values. We follow Gelfand et al. (2011) and adhere to the unidimensional conceptualization of practices of uncertainty avoidance by GLOBE.

is ambiguity in the solution to the error: several reactions to an error may eliminate the problem or prevent its re-occurrence. The way people approach ambiguity, as circumscribed by uncertainty avoidance, may thus have particular influence on the way errors are considered and dealt with. How errors are considered and dealt with are essential aspects of error management culture, and are therefore important for learning from errors. We thus argue uncertainty avoidance may particularly influence error management culture, and consequently learning from errors.

In countries high in uncertainty avoidance, errors may be evaluated more negatively (Gelfand et al., 2011). A negative evaluation of errors may, in turn, make error management culture and learning less likely. For the present study, we chose three countries that score very differently on the societal practices in uncertainty avoidance in the GLOBE project: while Hungary is low on uncertainty avoidance ($M = 3.12$; rank 60 of 62), the United States range in the middle ($M = 4.15$; rank 30), and Germany scores high ($M = 5.22$; rank 5; de Luque & Javidan, 2004). Following the argument that error management culture and learning from errors is higher in countries low on uncertainty avoidance, we would predict error management culture and learning from errors to be highest in Hungary, followed by the United States, and lastly Germany.

There is ongoing debate about whether country rankings can be used to predict individual behavior (e.g., Bond, 2002; Brewer & Venaik, 2012, 2014; Kirkman, Lowe, & Gibson, 2006). On the one hand, Brewer and Venaik (2012) argue that phenomena that are observable on a societal level “do not exist on individual level” (p. 674). Rather, country rankings should only be used to investigate relationships with other country level variables, such as a country's Gross Domestic Product. On the other hand, the perception of practices in a country may shape socialization patterns (Maccoby, 2000), personality (Triandis & Suh, 2002), and behavior (Adler & Gundersen, 2008; Singelis & Brown, 1995). We acknowledge

both sides of the debate, and therefore exercise caution in regard to how country rankings of any cultural dimension would predict individual learning from errors. We thus decided to put forth open research questions regarding country differences in favor of concrete hypotheses:

Open research question 1: Are there country differences in learning from errors?

Open research question 2: Are there country differences in error management culture?

Open research question 3: If there are country differences in learning from errors (Open research question 1), does error management culture mediate the relationship between country and learning from errors?

Overview of the Present Study

This study differs from our studies in Chapter 2 in three regards: First, Chapter 2 provided evidence that the affective error learning measure is an adequate proxy for learning from errors. Second, the present study was conducted in three different countries that score differently on the GLOBE uncertainty avoidance societal practices dimension, namely the United States, Hungary, and Germany. Third, in Study 2 in Chapter 2, we had only distinguished the experimental factor agent between “self” and “other”. However, according to social identity theory (Tajfel & Turner, 2004), there is a “tendency to favor the in-group over the out-group in evaluations and behavior” (p. 281). This would imply that the degree of learning that occurs might not only depend on the dichotomy (self and other) but may vary gradually with the agent. As a result of in-group favoritism, learning might be higher from errors made by an in-group member (e.g., close colleague), than from errors made by an out-group member (e.g., distant colleague). To test this assumption, the present study, thus, further subdivides the experimental factor agent.

Method

Sample

Participants were 588 working adults from the United States, Hungary, and Germany, recruited via eLancing websites. Mean age was 37.02 years ($SD = 10.76$) and 50 % were female. Participants' average work-experience was 15.11 years ($SD = 11.02$) and 10.7 % reported to hold a leadership position. Participants came from different industries, the most frequent were Information and Communication (13.6 %), Human Health and Social work activities (11.4 %), and Education (9.7 %). Participants received USD 2.40 (or its equivalent in Hungarian Forint or Euro) for participation (which corresponds to an hourly wage of approx. USD 9.00 and is thus above the minimum wage in all three countries). The criteria for inclusion of respondents in the survey were age (>18 years), place of residence (the United States, Hungary or Germany), and employment status (at least part-time employed).

Experimental Design and Procedure

Design and procedure of the present study were similar to those of the studies from Chapter 2, with the following differences. First, we included the country in which the sample was collected in as a between-participants factor. Second, the present study only employs the affective error learning measure. Third, the present study used three levels of the experimental factor agent (self, close colleague [i.e., from the same company], and distant colleague [i.e., from a different company]). As stated above, the degree of learning that occurs might not only depend on whether the error was made by oneself or someone else but may vary gradually with closeness of the agent, that is, whether the error was made by a close or a distant colleague. This resulted in a $3 \times (2 \times 3)$ mixed factorial design with country as between-participants factor (the United States, Hungary, or Germany), and severity of error consequences (mild vs. severe) and agent (self vs. close colleague vs. distant colleague) as within-participants factors.

Experimental Material

We used vignettes (i.e., six error scenarios) similar to those used in Chapter 2 that described typical errors at work.

Measures

Manipulation checks. To test whether participants perceived the severity of the error consequences in the intended way we used the same two questions as in the studies in Chapter 2. As expected, we found a large effect, $F(1,582) = 1117.01, p < .001, \eta_p^2 = .66$, indicating that our manipulations of severity of error consequences had worked as intended.

Dependent variable. Affective error learning was assessed with the same three items as in the studies in Chapter 2, adapted from the subscale “learning from errors” of the Error Orientation Questionnaire (EOQ; Rybowskiak, Garst, Frese, & Batinic, 1999). Cronbach's alpha was .95.

Error management culture. We assessed error management culture using the 17-item Error Management Culture Questionnaire (van Dyck et al., 2005). The Error Management Culture Questionnaire (van Dyck et al., 2005) is based on the Error Orientation Questionnaire (Rybowskiak et al., 1999) and is commonly used as a measure of error management culture in organizations (Frese & Keith, 2015). The Error Management Culture Questionnaire entails aspects of error competence, learning from errors, analyzing errors, and error communication. Sample items are “When people make an error, they can ask others for advice on how to continue” or “After an error, people think through how to correct it”. Participants had to indicate on a 5-point Likert scale how much the statements apply to their workplace. Cronbach's alpha was .93.

Results

Means, standard deviations, and correlations of variables used in the present study are presented in Table 3.1. Results indicated that error management culture was positively related to affective error learning. Error management culture was also related to country.

Table 3.1
Means, Standard Deviations, and Intercorrelations of Study Variables

	<i>M</i>	<i>SD</i>	1	2	3	4	5	6	7	8	9	10	11	12
Person characteristics														
1. Age	37.02	10.76	-											
2. Gender	-	-	.08											
Context factors														
3. Error Management Culture	4.00	0.67	.05	.00	(.93)									
Country														
4. The United States vs. Hungary and Germany	-	-	.00	.00	.29**	-								
5. Germany vs. the United States and Hungary	-	-	.01	.00	-.09*	-.49**	-							
6. Hungary vs. the United States and Germany	-	-	-.01	.00	-.20**	-.52**	-.49**	-						
Dependent variable affective error learning (overall and by levels of severity of error consequences and agent)														
7. Overall (aggregated across all levels)	4.07	0.67	.13**	.13**	.38**	.17**	-.06	-.11*	(.95)					
8. Mild error consequences	4.01	0.73	.12**	.13**	.35**	.18**	-.08	-.10*	.94**	(.94)				
9. Severe error consequences	4.12	0.72	.12**	.11**	.35**	.13**	-.04	-.09*	.93**	.75**	(.92)			
10. Self	4.26	0.71	.15**	.09*	.36**	.16**	-.01	-.15**	.81**	.76**	.75**	(.89)		
11. Close colleague	3.97	0.82	.12**	.15**	.32**	.14**	-.04	-.10*	.88**	.82**	.82**	.55**	(.92)	
12. Distant colleague	3.96	0.82	.08*	.09*	.30**	.14**	-.10*	-.03	.88**	.82**	.83**	.57**	.68**	(.93)

Note. *N* = 588. Cronbach's alpha coefficients are shown in parentheses along the diagonal. Gender was coded 0 for male and 1 for female.

* $p < .05$. ** $p < .01$.

¹Factor 1: severity of error consequences (mild, severe); Factor 2: agent (self, close colleague, distant colleague).

Severity of Error Consequences, Agent, and Error Management Culture

Hypothesis 1 predicted that severity of error consequences increases learning from errors in that learning is higher for errors with severe consequences. Hypothesis 2 predicted that learning from errors depends on the agent in that learning is higher when the error was made by oneself as opposed to by someone else. Hypothesis 3 predicted that error management culture is associated with learning from errors in that learning is higher if more error management culture is experienced. We tested the hypothesized effects simultaneously in a repeated measures ANCOVA in which we included material version (i.e., vignette-factor combination) as between-participants control factor (Judd, Kenny, & McClelland, 2001). Error management culture was mean-centered and included as a between-participants covariate (Cohen, Cohen, West, & Aiken, 2003). In support of our hypotheses, we found a main effect of severity of error consequences on affective error learning, $F(1,581) = 27.49, p < .001, \eta_p^2 = .05$ (see Figure 3.1, Panel a), and a main effect of agent, $F(2,1162) = 71.65, p < .001, \eta_p^2 = .11$ (see Figure 3.1, Panel b).^{2,3} Learning from errors was higher if the error was made by oneself ($M = 4.23, SD = 0.03$) than made by a close colleague ($M = 3.93, SD = 0.03$), $t(587) = 9.67, p < .001, d = 0.38$, or distant colleague ($M = 3.92, SD = 0.03$), $t(587) = 10.52, p < .001, d = 0.39$. Learning from errors did not differ for errors made by a close colleague or distant colleague, $t(587) = 0.56, p = .57, d = 0.01$. Furthermore, error management culture was significantly associated with affective error learning, $F(1,581) = 96.17, p < .001, \eta_p^2 = .14$.

Country Differences in Learning from Errors

Our first open research question addressed whether there are country differences in

² Due to the violation of the sphericity assumption in case of agent, a Huynh-Feldt corrected F -value (as the ϵ estimates of sphericity were greater than 0.75) was applied (Girden, 1992).

³ The other effects in the ANCOVA (not pertinent to the hypothesis) were as follows. No main effect of material version, $F(5,581) = 0.66, p = .66, \eta_p^2 = .01$, but an interaction effect of material version with severity of error consequences, $F(5,581) = 12.78, p < .001, \eta_p^2 = .10$, and with agent, $F(10,1162) = 4.16, p < .001, \eta_p^2 = .03$.

learning from errors. We tested our first open research question in a repeated measures ANOVA in which we included a multicategorical independent variable for country (the United States vs. Hungary vs. Germany) and the material version (i.e., vignette-factor combination) as between-participants control factor (Judd et al., 2001). We found a significant relationship between country and affective error learning, $F(2,570) = 9.00, p < .001, \eta_p^2 = .03$, indicating that learning differs between the United States, Hungary, and Germany (see Figure 3.1, Panel c). However, contrary to our assumption, learning from errors was significantly higher in the United States ($M = 4.23, SD = 0.64$) than in Hungary ($M = 3.97, SD = 0.76$), $t(399) = 3.94, p < .001, d = 0.37$, and also than in Germany ($M = 4.00, SD = 0.57$), $t(386) = 3.31, p < .01, d = 0.38$. Hungary and Germany did not differ significantly, $t(385) = 0.56, p = .57, d = 0.04$.

The other results in the repeated measures ANOVA (not pertinent to the hypothesis) were as follows. No interaction of country and severity, $F(2,570) = 2.09, p = .13, \eta_p^2 = .01$, and no interaction of country and agent, $F(4,1140) = 2.16, p = .07, \eta_p^2 = .01$.⁴

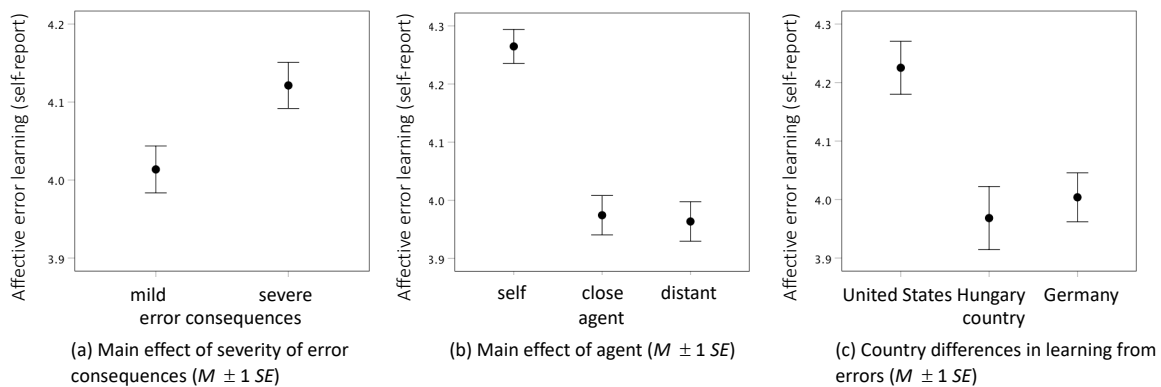


Figure 3.1. Main effect of severity of error consequences and agent on learning from errors, and country differences in learning from errors.

⁴ Due to the violation of the sphericity assumption in case of agent, a Huynh-Feldt corrected F -value (as the estimates of sphericity were greater than 0.75) was applied (Girden, 1992).

Country Differences in Error Management Culture

Our second open research question asked whether there are differences in error management culture between countries. To test our second open research question, we conducted a univariate ANOVA. We found a significant main effect of country on error management culture, $F(2,585) = 28.37, p < .001, \eta_p^2 = .09$. Participants in the United States ($M = 4.27, SD = 0.56$) reported significantly more error management culture, than did participants in Germany ($M = 3.91, SD = 0.57$), $t(386) = 6.21, p < .001, d = 0.63$, or Hungary ($M = 3.81, SD = 0.76$), $t(399) = 6.84, p < .001, d = 0.69$. Hungary and Germany did not differ significantly, $t(385) = 1.41, p = .16, d = 0.15$.⁵

Potential Mediation of Error Management Culture

Our third open research question asked whether error management culture mediates the relationship between country and learning from errors. To test this open research question, we conducted mediation analysis (using 5000 bootstrap samples) with our multicategorical independent variable, country, as predictor (Preacher & Hayes, 2004; Hayes & Preacher, 2014), error management culture as mediator, and learning from errors (affective error learning) as criterion variable. Based on our previous results that learning from errors and error management culture is highest in the United States, and that Hungary and Germany did not differ in error management culture and learning, we only created one dummy variable (“United States vs. Hungary and Germany”) for the multicategorical independent variable, country, with codes of ($\frac{2}{3}, -\frac{1}{3}, -\frac{1}{3}$) for the United States, Hungary, and Germany, respectively. (We reran the mediation analysis with two Helmert-coded dummy variables with codes of [$\frac{2}{3}, -\frac{1}{3}, -\frac{1}{3}$] and [$0, -\frac{1}{2}, \frac{1}{2}$] for the United States, Hungary, and Germany, respectively. The pattern and magnitude of results remained unaltered.) Again, we controlled for material version (i.e.,

⁵ In Chapter 2, we found the same pattern of results for country differences in error management culture. Participants from the United States ($M = 4.22, SD = 0.52$) reported significantly more error management culture than did participants from Germany ($M = 3.81, SD = 0.50$), $t(237) = 6.25, p < .001, d = 0.80$.

vignette-factor combination). We found a significant positive relationship between our dummy variable “United States vs. Hungary and Germany” and error management culture (Figure 3.2, path a). We also found a significant positive relationship between error management culture and affective error learning (Figure 3.2, path b). The 95 % bias corrected confidence interval for the indirect effect excluded zero, indicating a significant indirect relationship for our dummy variable “United States vs. Hungary and Germany”, $b = 0.15$, CI [0.09, 0.20] (see Figure 3.2). In other words, the results are consistent with the idea that error management culture mediates the relationship between country and learning from errors.

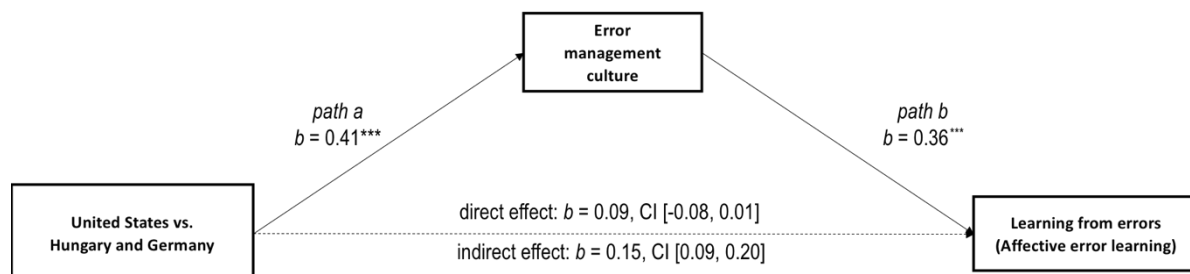


Figure 3.2. The relationship between country and learning from errors mediated by error management culture. Unstandardized values and confidence intervals (CI). The dashed arrow indicates the non-significant direct path from country to learning from errors. *** $p < .001$.

Discussion

In the present research, we demonstrated that learning from errors not only depends on error characteristics such as severity of error consequences or the agent who made the error, but also on the cultural context in which the error occurred. More specifically, in a vignette experiment, we were able to replicate the results from our studies in Chapter 2, namely, that learning was more likely when (a) the consequences of the errors were severe as opposed to mild, when (b) the error was made by oneself as opposed to by someone else. Who the other person was did not matter: We found no difference in learning from errors made by close and distant colleagues. Furthermore, we found that more learning from errors occurred (c) when error management culture was high. We also demonstrated that participants in the United States

(d) report more error management culture, and (e) learned more from errors than participants in Hungary or Germany. Further, we showed that (f) the differences in learning from errors were due to differences in error management culture.

Theoretical Contributions

Our results regarding severity of error consequences and agent are in line with the results found in Chapter 2. As these results were discussed in detail in Chapter 2, here, we only discuss the result regarding error characteristics that we did not find differences in learning from errors made by in- and outgroup members. One potential explanation for this result is that we used vignette-methodology with hypothetical error situations. Participants might not be able to clearly identify with their in-group in a hypothetical error situation. This could indeed reduce in-group favoritism. Another explanation might be that the in-group member making an error is seen as failure. In-group favoritism might indeed depend on whether the group-outcome is success or failure. For example, Ryen and Kahn (1975), as well as Brewer (1979) found that in-group favoritism disappeared when the in-group received the feedback that their group did not succeed. This would explain our result that learning did not differ between errors made by in-group and out-group members.

To the best of our knowledge, the present study is the first to assess how error management culture and learning from errors differs between countries. In order to do so, we selected three countries that differ in regard to the practices of uncertainty avoidance (House et al., 2004): the United States, Hungary, and Germany. Although we had put forth open research questions regarding the country differences in error management culture and learning from errors, we had assumed that amongst others, uncertainty avoidance may have particular influence on how people deal with errors (i.e., error management culture), thus learning from errors (Gelfand et al., 2011). Specifically, we had assumed a linear effect of uncertainty avoidance on error management culture and learning from errors, predicting learning from

errors to be highest in Hungary, to be moderate in United States, and to be lowest in Germany. However, we found an inverted u-shaped relationship: error management culture and learning was highest in the United States (which, according to the GLOBE project, scores moderately on practices of uncertainty avoidance; de Luque & Javidan, 2004), and lower in Hungary (low in practices of uncertainty avoidance), and Germany (high on practices of uncertainty avoidance; de Luque & Javidan, 2004). An explanation for these results may be that in countries low in uncertainty avoidance, errors may not be taken seriously enough, which inhibits their learning potential. However, when uncertainty avoidance is high, errors may be considered to be too threatening. This may lead to defensive reactions, which may also reduce the learning potential of the errors. The optimum would thus lie in the middle, at moderate levels of practices of uncertainty avoidance.

However, it could be that another cultural dimension, namely humane orientation influences how people deal with and learn from errors. *Humane orientation* refers to the extent to which a society “encourages and rewards individuals for being fair, altruistic, friendly, generous, caring, and kind to others” (House & Javidan, 2004, p. 13). Humane orientation may influence error management culture and learning from errors, because it “is related to increased compassion and acceptance and thus acceptance of mistakes” (Gelfand et al., 2011, p. 260). Countries high on humane orientation can thus be described as more error tolerant. In the GLOBE study, one item examines how error tolerant people are in the respective country. This item on error tolerance is part of the humane orientation scale (Kabasakal & Bodur, 2004). When errors are more tolerated and expected to happen, emotions associated with errors should be less negative (Frese & Keith, 2015). This may foster an environment in that learning from error may be more likely. According to the GLOBE study, Germany ($M = 3.18$; rank 61 of 62) and Hungary ($M = 3.35$; rank 58) are lower on humane orientation practices than the United States ($M = 4.17$; rank 26; Kabasakal & Bodur, 2004). Following the reasoning that error

management culture and learning from errors is higher in countries high on humane orientation, error management culture and learning from errors should be highest in the United States, followed by Hungary and Germany. This corresponds to the pattern of results that we found in our study. We argue that humane orientation fosters learning from errors because humane orientation may be associated with error tolerance. This may seem like a contradiction to our hypothesis that errors need to be severe enough to stimulate learning. We believe that this seeming contradiction can be reconciled: Error tolerance means that it is accepted that errors may happen despite efforts to prevent them. This positivity may stem from the assumption that errors can be corrected. Error tolerance does not mean that errors are not taken seriously. We argue that errors need to be taken seriously to evoke learning. This is in line with our argumentation that more learning from errors occurs when error consequences are severe rather than mild, because errors with severe consequences are taken more seriously. However, it has to be noted that the concept of humane orientation as defined by GLOBE is subject of debates. For example, Schlösser and colleagues (2013) point out that humane orientation is an ambivalent, multidimensional construct. The GLOBE humane orientation scale as such has rather poor psychometric properties and validation evidence.

Another alternative explanation for our results regarding country differences in learning from errors may lie in the litigious nature of the United States. The United States are considered to be a more litigious country than Germany or Hungary. In litigious countries, seemingly small incidents can *develop* severe consequences, such as a tort case with the threat of high compensation payments. When each error may develop severe consequences, each error may be taken seriously. Thus, we would assume more learning from errors to occur in the United States than in Germany or Hungary. This may explain why participants in our United States sample learned most of errors, regardless of the *manipulated* severity of the consequences.

Further, we had assumed that country differences in learning from errors are due to

differences in error management culture. We identified error management culture as mediator in the relationship between country and learning from errors.

Strengths, Limitations, and Directions for Future Research

Using country rankings as predictors for individual behavior has been criticized for long (e.g., Brewer & Venaik, 2012, 2014; Bond, 2002). According to Brewer and Venaik (2012), societal level phenomena “do not exist on individual level” (p. 674). In a similar manner, Schwartz argues that “cultural value orientations are properties of societies, not of individuals” (2009, p. 146). Furthermore, Minkov and Hofstede argue that dimensions of national culture “are meaningless as descriptors of individuals or as predictors of individual differences because the variables that define them do not correlate meaningfully across individuals” (2011, p. 12). The assumption that similar characteristics and relationships exist at the cultural and individual level has been labeled ecological fallacy (e.g., Brewer & Venaik, 2012, 2014; House & Hanges, 2004). Brewer and Venaik (2012) further argue that one may not associate societal level phenomena, such as practices of uncertainty avoidance, with phenomena on an individual level, such as individual behavior. Instead, one may only investigate relationships of societal level phenomena with societal level variables, such as the Gross Domestic Product. In that sense, GLOBE's uncertainty avoidance practices scores are not a measure or predictive of individual behavior, but represent how participants perceive the practices in the society.

However, several researchers argue that there may well be an influence of country level variables on individual behavior. For example, how practices in a country are perceived can influence socialization patterns (Maccoby, 2000), personality (Triandis & Suh, 2002), and behavior (Adler & Gundersen, 2008; Singelis & Brown, 1995). This may be because the perceptions of what is prevailing, what is considered to be right or wrong, may shape “the knowledge about and attitudes towards life” (Geertz, 1973, p. 89), and the norm of how people feel one expects them to behave.

We acknowledge the caveats as noted above (e.g., Brewer & Venaik 2012, 2014). However, we also acknowledge the line of reasoning that perception of the practices in a country may influence individual behavior. It has to be noted that of course, not every individual in a country must behave accordingly, but we believe that the practice scores of a cultural dimension may adequately pinpoint to a general behavioral tendency of individuals in the respective country. De Mooij (2013) argues that “scores on national dimensions cannot be used to predict the behavior of a particular individual, but as long as authors are clear about reporting frequencies or averages, using the word individuals is not problematic. (...) Individuals in a national society are like the pieces in a jigsaw puzzle; while each being unique, they fit together and produce a meaningful national picture. In describing the national culture, it is perfectly okay to refer to characteristics of individuals that in such a culture are relatively more frequent or more likely”. Taken together, we had decided to exercise caution regarding potential country differences in learning from errors and had put forth open research questions in favor of concrete hypotheses.

Another limitation of our study is that we cannot be sure whether people actually learn(ed) more from errors in the United States or whether our results are due to a response bias, the acquiescence bias.

Another potential limitation is that we collected data on error management culture and learning from errors from the same persons. Due to the common source bias, the results might be inflated. We therefore encourage further studies that use data from different sources in order to further assess the relationship between error management culture and learning from errors. Also, error management culture was assessed on the individual level even though error management culture is a concept on the organizational level. Future studies may assess responses regarding error management culture of more than one person from an organization and analyze data on the aggregated organizational level.

One of the strengths of our study is that we tested our assumptions in more than one country. Our results, namely, that learning from errors differs between countries, demonstrate the importance of cross-cultural research on learning from errors. Another strength of our study is our design, as we applied experimental vignette methodology using carefully developed and pretested error scenarios. We included manipulation checks and statistically controlled for experimental material. Furthermore, we had a large sample size of 588 participants from three different countries.

In the ongoing replication crisis in psychology and other fields (Open Science Collaboration, 2015), replication of results is important to minimize the possibility of false positive findings. In this regard, one of the strengths of the present paper is that we were able to find the suggested pattern across three independent samples from three countries.

Practical Implications

Our study demonstrated that learning from errors differs significantly depending on characteristics that lie within the error itself (e.g., severity of its consequences) as well as on factors lying outside the error (e.g., agent who makes the error). We also found that learning from errors differs between countries and that more learning occurs when more error management culture is experienced. Apparently, not the error per se and its informational value determines whether people use it for learning. Rather, superficial characteristics of the error situation (such as the person who made the error) determine whether people are willing to devote more attention to the error and subsequently learn from it.

Our results suggest that errors with mild consequences and errors made by someone else do not receive as much attention as errors with severe consequences or errors made by oneself. The learning potential inherent in errors, thus, is not fully exploited. In order to foster learning from errors for employees, organizations should develop interventions that actively

encourage learning from errors and raise attention even to errors with mild consequences. Furthermore, organizations should foster an error management culture in their teams – a culture in which errors may be openly discussed and are considered as positive events. A non-threatening atmosphere could foster an open discussion about errors and turn attention to errors that would have otherwise been overlooked because they were not severe or visible enough to catch attention. Moreover, by fostering an open discussion about errors between colleagues, one is able to learn about and from errors made by someone else. While developing interventions regarding errors, organizations should also take into account country specific characteristics, norms, and habits. Our insights can be used to develop interventions to improve the way people deal with errors in organizations, as well as to raise attention to the importance of country specific issues.

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4

How To Induce an Error Management Culture: Experimental Evidence from Newly Formed Teams

Abstract

Field studies have shown that error management culture benefits organizational performance. However, the question whether and how an error management culture can be induced remained unanswered. We conducted an experiment with newly formed teams ($N = 180$ participants (60 triads)), in which we aimed to induce an error management culture. Furthermore, we sought to replicate the pattern of results concerning error management culture and performance found in field studies. We attempted to induce an error management culture in two ways. First, we used an error management culture manipulation based on error management training instructions that encourages exploration and learning from errors. Second, we used an error management culture manipulation based on normative social influence. Additionally, we used an error prevention culture manipulation as a

The research presented in this dissertation was supervised and supported by Nina Keith and Michael Frese.

Parts of this chapter will be presented at the 35th Annual Conference of the Society for Industrial and Organizational Psychology in Austin, TX.

control condition. Participants were randomly assigned to one of three experimental conditions: error prevention culture manipulation, error management culture manipulation based on error management training instructions, or error management culture manipulation based on normative social influence. Participants had to work together in teams on creative problem-solving tasks. We were able to experimentally replicate the beneficial effect of error management culture on performance found in field studies in a creative problem-solving task. Furthermore, we successfully influenced groups' perception of error management culture with manipulations based on error training instructions. The error management culture manipulation based on error training instructions led to higher perception of error management culture in teams, and thus to higher performance. However, the effects persisted over time only when culture strength (i.e., the agreement about culture between group members) was high. By studying error management culture in standardized laboratory settings, we aim to contribute to the theoretical understanding of the effect of error management culture. For practitioners, we aim to provide insights into how an error management culture can be induced in teams.

In the previous two chapters, we demonstrated that the amount of learning from errors depends on (a) different error characteristics, such as the severity of error consequences or the agent who made the error, as well as on (b) contextual factors, such as the perceived organizational culture (e.g., error management culture) or country. In our studies, more learning occurred from errors with severe as opposed to mild consequences and when the error was made by oneself as opposed to by someone else. We also found learning from errors to be highest in the United States, followed by Germany and Hungary. Moreover, we found that more learning from errors occurred when more error management culture was experienced. In this chapter, we shift the focus from the individual to the team level, and examine whether

the beneficial effect of error management culture on learning from errors can also be extended to performance-related outcomes.

Error management denotes a “useful approach to errors with the goal of reducing future errors, of avoiding negative error consequences and of dealing quickly with error consequences once they occur” (Frese, 1995, p. 113). Error management culture applies the principles of error management to the team or organizational level. An error management culture has been shown to positively predict performance in terms of innovativeness (e.g., Fischer, Frese, Mertins, & Hardt-Gawron, 2018), profitability, goal achievement, survivability (e.g., van Dyck, Frese, Baer, & Sonnentag, 2005), and safety (e.g., Hofmann & Mark, 2006). However, previous studies on error management culture have mainly two aspects in common: (a) they studied the effects of error management culture on the aggregated, organizational level instead of the more fine-grained team level, and (b) they are field studies. While field studies have the advantage of high ecological validity, external influences can hardly be excluded. We believe that this may be problematic, as many factors may play an important role and influence organizational performance, for example the management's leadership, the industry in which the company operates, as well as other cultural factors that go above and beyond the error management culture.

Another shortcoming of these field studies is that they neglected the question of how an error management culture can be induced in teams, so that team members commonly adopt positive views on errors. This question is particularly important, as in most if not all organizations, team and organizational members fluctuate over time: Teams may exist and remain unchanged for years, or team members may join and leave frequently. Understanding how an error management culture may be induced does not only contribute to our theoretical knowledge, but is also relevant for practitioners in order to understand drivers of change. We thus believe it is highly relevant to study error management culture in an experimental setting,

thereby allowing standardization and exclusion of confounding variables rather than statistically controlling for them.

The aim of the present studies is thus twofold: First, we aim to induce an error management culture in teams. By grouping strangers into teams, we have the opportunity to attempt to experimentally induce an error management culture. Second, we further seek to replicate the beneficial effects of error management culture on performance reported in field studies in an experimental setting.

Our research shall contribute to the existing literature in the following ways. First, from a theoretical perspective, by studying how an error management culture can be induced, we aim to shed light on questions regarding the drivers of change and innovation effects. Second, from practitioner perspective, the question of how to induce an error management culture is highly important. Third, from an empirical perspective, we believe that we are the first ones to experimentally induce error management culture and to investigate the beneficial effects of error management culture on performance. Experimental studies on error management have been conducted on the individual level (e.g., Chillarege, Nordstrom, & Williams, 2003; Dormann & Frese, 1994; Frese, Brodbeck, Heinbokel, Mooser, Schleiffenbaum, & Thiemann, 1991; Heimbeck, Frese, Sonnentag, & Keith, 2003; Keith, 2011; Keith & Frese, 2005; for a meta-analysis, see Keith & Frese, 2008) and do not shed light on questions that are culture-specific.

Theory and Hypotheses

Error Management Culture

Most (if not all) organizations make errors. Because every organization is confronted with the possibility that errors may happen, organizations implicitly or explicitly adopt some shared norms, practices, and procedures of dealing with errors. These shared assumptions, values, practices, and norms constitute an organizational culture (Reichers & Schneider, 1990;

Schein, 2004) – i.e., error management culture¹. *Error management culture* applies the principles and practices of error management to the team or organizational level. *Error management* is a perspective towards errors that disentangles errors from their consequences. The aim is not to avoid an error per se, but to avoid negative consequences that may result from unmanaged errors. Above and beyond that, error management aims to foster positive consequences that may result from errors, such as learning and innovation (e.g., Sitkin, 1992, Keith & Frese, 2011, Fischer et al., 2018).

Error Management Culture and Performance

We posit that error management culture positively relates to performance in teams. Common practices and principles of error management culture, such as the open communication about errors, knowledge-sharing, quick error detection, coordinated error handling, and thus quick damage control help to decrease negative error consequences and increase positive error consequences such as learning from errors or secondary error prevention (van Dyck et al., 2005). When error management culture is high, team members accept errors and expect them to happen, are more vigilant, and anticipate errors better. In turn, quick error detection allows to minimize negative error consequences (Keith & Frese, 2011). Furthermore, when error management culture is high, team members do not fear blame and punishment for errors and are encouraged to manage errors and learn from them (van Dyck et al., 2005; Frese & Keith, 2015). Team members are thus more willing to experiment or explore (van Dyck et al., 2005; Dormann & Frese, 1994; Keith & Frese, 2008). Exploration and experimentation, in turn, foster innovativeness (Fischer et al., 2017).

This is in line with empirical evidence that suggests error management culture to be beneficial for organizational outcomes such as safety, innovativeness, and performance in

¹While it can be argued that this description is more applicable to a climate than a culture (e.g., Denison, 1996; Reichers & Schneider, 1990), we stick to the term *error management culture* that has been introduced by van Dyck et al. (2005).

terms of firm profitability (e.g., Fischer et al., 2018; Hofmann & Mark, 2006; Keith & Frese, 2011; van Dyck et al., 2005). However, the questions remain whether the beneficial effects of error management culture on performance reported in field studies can also be observed under standardized conditions and exclusion of confounding variables. In sum, both theory and empirical evidence suggest error management culture to benefit performance. We hypothesize:

Conceptual Hypothesis: Error management culture positively predicts team performance (Figure 4.1).

We operationalize our conceptual hypothesis by attempting to induce an error management culture. Research agrees that error management culture beneficially influences performance related outcomes (van Dyck et al., 2005; Fischer et al., 2018, Hofmann & Mark, 2006). However, despite these positive findings, research is scarce whether and if so, how an error management culture in teams or organizations can be established. To at least partially answer this question, we have to take a closer look on the etiology of organizational cultures.

The Creation and Change of Organizational Culture

There are three approaches to the etiology of organizational culture²: the structural, the perceptual, and the interactive approach³ (Schneider & Reichers, 1983; Moran & Volkwein, 1992). According to the structural approach (Payne & Pugh, 1976), people's shared values, norms, and assumptions arise as an exposure to the organization's characteristics and structure. There are two main problems with the structural approach. First, several studies found subcultures within an organization (e.g., Sackmann, 1992). Based on the argumentation of the

² These approaches are originally described as the approaches to the etiology of climate. However, we use the terms culture and climate interchangeably, due to our definition and understanding of the error management culture concept (see Footnote 1).

³ Moran and Volkwein (1992) introduced a fourth approach, the cultural approach. The cultural approach can be seen as an extension of the interactive approach that counts for the broader context in which the group members interact and respond to the situation. Under broader context, the authors refer to organizational culture and explicitly differentiate culture and climate.

structural approach, there should only be one perception of culture within an organization. Second, the results concerning the relationship of organizational structure elements and culture is inconsistent (Berger & Cummings, 1975, Cummings & Berger, 1976).

The perceptual approach (see also, perceptual measurement-individual attribute approach (James & Jones, 1974) and selection-attraction-attrition or attraction-selection-attrition approach (SAA or ASA, Schneider & Reichers, 1983; Schneider, 1987)) argues that the culture is formed while individuals interpret and respond psychologically meaningfully to situational variables (Moran & Volkwein, 1992). The main limitation of this approach is that it puts the source of the assumptions, meaning, and beliefs within the individual (Schneider & Reichers, 1983).

The interactive approach “blends the objectivism and subjectivism of these [previously described] approaches” (Ashforth, 1985, p. 837). Culture is formed while group members interact with each other and respond to their situation, which results in shared meaning, assumptions, and values (Moran & Volkwein, 1992). Both informational and normative social influence are key processes while group members interact (Ashforth, 1985). The interactive approach is in line with Schein's (1983) and our understanding that organizational culture emerges in two ways. First, a culture emerges while an organization invents, discovers or develops basic assumptions while “learning to cope with its problems of external adaptation and internal integration – a pattern of assumptions that has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way to perceive, think, feel, and behave in relation to those problems” (Schein, 1983, p. 14). Second, a culture emerges when founders formulate ideologies, norms, strategies and “influence followers to adopt them” (Trice & Beyer, 1993, p. 414). It is, thus, “possible to influence the kinds of perceptions that individuals have” (Schneider & Reichers, 1983, p. 36) by top-management with the use of adequate skills and resources (Alvesson & Svenningsson, 2008). In sum, culture

arises from three sources: 1) the founder's (or leader's or manager's) beliefs, values, and assumptions; (2) the learning experiences of group members while confronted with various problems; and (3) new values of new members (Schein, 2004).

If organizational culture emerges as a result of the founder's influence or develops over time while group members interact, that implies that culture is changeable. Sathe and Davidson (2000) reviewed the cultural change literature and concluded that changing (at least some) values and beliefs is indeed possible. However, there is disagreement between authors whether change of deep beliefs and values is achievable, or if only a superficial change (the compliance of members) can be achieved (Sathe & Davidson, 2000). According to Sathe and Davidson (2000), cultural change can be seen as the process of what Lewin (1951) proposed as “unfreezing, moving, and freezing of group standards” (p. 228). The biggest question in the process is “whether behaviors or minds are the best targets for change” (Sathe and Davidson, 2000, p. 282), thus whether (and when) intrinsic or extrinsic forms of reinforcement should be used. Sathe and Davidson (2000) argue that both intrinsic motivators (that effect behavior change) and extrinsic motivators (that effect change in values and beliefs) should be used in the change process. While there is no panacea for successful emergence and change processes, it is evident that culture can be formed and changed.

Inducing an Error Management Culture

While it is evident that (organizational) culture can be established and changed, the question of how an (organizational) culture regarding errors (i.e., error management culture) can be induced remains unanswered. To answer this question, we conducted an experimental study in which we tried to induce an error management culture covering different aspects of the principles and practices of error management culture. For this purpose, we developed two different error management culture manipulations.

First, we developed a manipulation based on normative social influence. The interactive

approach to the etiology of culture considers normative social influence as a key factor in the formation of organizational culture (Ashforth, 1985). Normative social influence can be defined as “an influence to conform with the positive expectations of another” (Deutsch & Gerard, 1955, p. 629). Several studies demonstrated the power of normative social influence on people's behavior (e.g., Sherif, 1935; Deutsch & Gerard, 1955; Asch, 1955, 1956; Cialdini, Reno, & Kallgren, 1990; Schultz, 1999; Schultz, Nolan, Cialdini, Goldstein, & Griskevicius, 2007; Nolan, Schultz, Cialdini, Goldstein, & Griskevicius, 2008; Milgram, Bickman, & Berkowitz, 1969; for a review see Cialdini & Goldstein, 2004). Moreover, studies demonstrated that a direct observation of others is not a requirement for normative social influence to take effect on people's behavior (e.g., Schultz, 1999; Parks, Sanna, & Berel, 2001; Goldstein, Cialdini, & Griskevicius, 2008). “Communicating a descriptive norm – how most people behave in a given situation – via written information can induce conformity to the communicated behavior” (Nolan et al., 2008, p. 913). For example, in a study from Goldstein and colleagues (2008), hotel guests received written messages about participation in a towel reuse program: “Join your fellow guests in helping to save the environment. Almost 75% of guests who are asked to participate in our new resource savings program do help by using their towels more than once. You can join your fellow guests in this program to help save the environment by reusing your towels during your stay.” (p. 474). The appeal employing written descriptive norms resulted in a higher towel reuse rate.

Second, we developed a manipulation based on error management training instructions. Error management training “is an active learning approach that emphasizes experimentation and exploration by participants rather than a tight structure and the guidance of participants” (Frese & Keith, 2015, p. 672). Error management training has been shown to be more effective than alternative training methods which do not encourage learning (e.g., Bell & Kozlowski, 2008; Heimbeck et al., 2003; Carter & Beier, 2010; Keith & Frese, 2005; for a meta-analysis

see Keith & Frese, 2008). In error management training, participants are only provided with minimal guidance and structure. This way, error management training fosters exploration of the task by enhancing the informative feedback of errors (Keith & Frese, 2005). Error management training acknowledges the positive and informative function of errors during training (Ivancic & Hesketh, 1995/1996; Keith & Frese, 2008). Moreover, trainees are explicitly encouraged to make errors, appreciate the informative functions of errors, and to learn from errors: “You have made an error? Great! Because now you can learn something new!” (Keith & Frese, 2008, p. 60). Error management training, however, focuses on the individual level. In our study, we aimed at inducing error management culture by using error management training instructions but applying them to the team level. We thus hypothesize:

Operational Hypotheses: An error management culture manipulation fosters error management culture (as perceived by the team) and thus performance (Figure 4.1).⁴

Operational Hypothesis a: An error management culture manipulation based on normative social influence fosters error management culture (as perceived by the team) and thus performance.

Operational Hypothesis b: An error management culture manipulation based on error management training instructions fosters error management culture (as perceived by the team) and thus performance.

⁴ In order to avoid potential confusions with our experimental manipulation, we refer to our measure of error management culture as *error management culture (as perceived by the team)*.

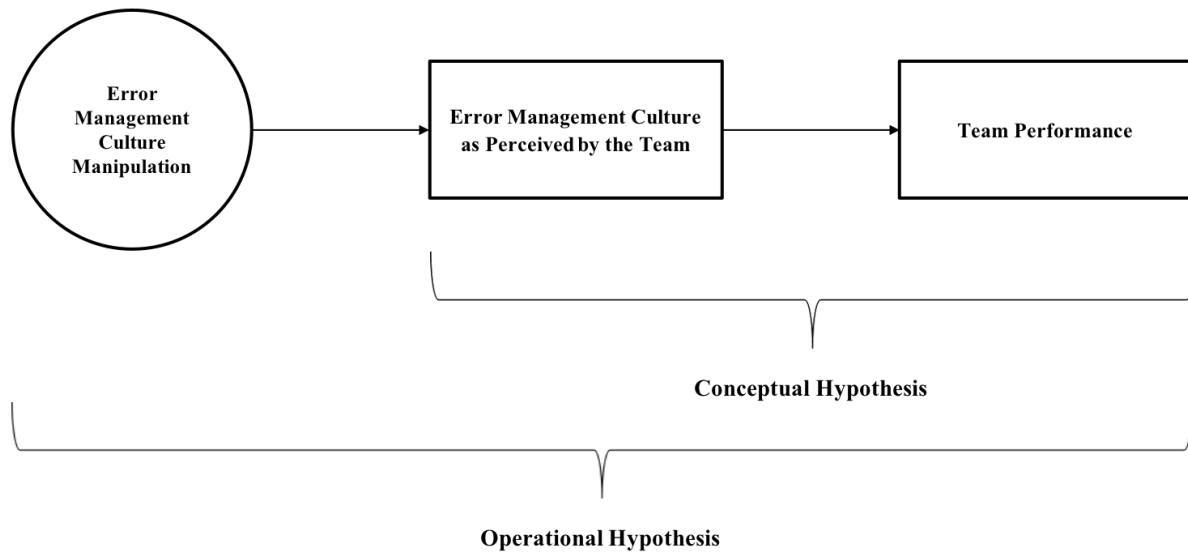


Figure 4.1. Conceptual and operational hypothesis.

Literature suggests that culture persists over time (e.g., Schein, 1983; Ehrhart, Schneider, & Macey, 2014; Kotter & Hesketh, 1992). This is in line with the assumption that norms form quickly and are stable over time (Sherif, 1936). An indicator, thus, of whether we actually succeeded in inducing an error management culture would be that the effect of our manipulations on error management culture (as perceived by the team) and thus performance persists over time. We thus put forth an open research question:

Open research question: Does the effect of error management culture manipulations on error management culture (as perceived by the team) and thus team performance persist over time?

Method

Sample

Participants were 180 students ($N = 60$ triads) of a German university. Mean age was 25.76 years ($SD = 10.12$) and 41.1 % were female. Most of the participants (68.9 %) worked at least part-time. Participants received either EUR 8 (approx. USD 9.50) or partial course credit as compensation.

Experimental Design and Procedure

We invited participants to our laboratory to work on a team tasks that requires creative problem solving, namely the “Marshmallow Challenge” and a marble run task.

The Marshmallow Challenge is commonly used at team-building workshops and trainings (Wujec, 2010) but also for experimental purposes (e.g., Cook & Olson, 2006; Steele, Hardy, Day, Watts, & Mumford, 2019). In the Marshmallow challenge, participants' task was to use spaghetti to build a structure, and to place a marshmallow on top. The challenge was to build the highest standing structure. The group who builds the highest structure would win an additional prize in form of a voucher for an online retailer⁵. The marble run task is a construction task similar to the “rolling ball” task used in previous experiments from Tschan (1995, 2002). In the marble run task, participants had to build a ball track system that is a “roller coaster structure for marbles” (Tschan, 1995, p. 376). The challenge was to build the highest functioning marble run, to use as many pieces as possible to build the marble run, and to create a route in which the marble runs as long as possible. Again, the best performing group would win an additional prize in form of a voucher for an online retailer.

We chose these tasks for the following five reasons. First, in these tasks team performance can be measured meaningfully and objectively. Second, these tasks do not require previous knowledge and are simple enough to be learned within a one-time laboratory session. Third, the tasks entail certain degrees of freedom with regard to how to arrive at a solution (i.e., a task that involves one single-best solution that needs to be found by the team would not be suitable). Fourth, in these tasks, participants can clearly see and know when they made an error (i.e., the structure in the Marshmallow Challenge collapses). The tasks deliver immediate feedback if an error has happened. Fifth, the tasks require a minimum of coordination and

⁵In line with ethical standards and to avoid disadvantages for participants of any experimental condition, we in fact rewarded the best performing group in each condition.

communication among team members so that it makes sense for the team members to communicate about errors (i.e., tasks that can be completely subdivided and worked on individually without further team coordination would not be suitable).

After arrival in our experimental laboratory, we briefly welcomed our participants and asked them to individually complete questionnaires regarding demographics and their attitudes about errors. Then, we grouped individual participants from the same session into teams of three and randomly assigned the teams to one of three experimental conditions (between-participants design with one experimental factor, error framing condition): (1) *Error management culture manipulation based on normative social influence*, (2) *Error management culture manipulation based on error management training instructions*, or (3) *Error prevention culture manipulation*. Our manipulations focused on how participants should deal with errors in the process of the team task. We used two error management culture manipulations, in which we covered different aspects of the principles of error management culture.

In the *Error management culture manipulation based on normative social influence (EMC-social influence)*, we informed participants about the beneficial effects of errors. Similar to the study by Goldstein and colleagues (2008), in our study, people received error management culture principles and practices as written descriptive norms. In particular, we told participants that the most successful groups in previous rounds of task execution were those that “made the most trials and also made the most errors! 90% of the most successful groups openly discussed errors. That way it was possible to learn from errors as a team and to improve further. This does not only apply to the [task used in this study]. Studies have shown that companies that see errors as a learning opportunity are much more successful.” (extraction; for the manipulations used in this study see Appendix B).

In the *Error management culture manipulation based on error management training instructions (EMC-error exploration)*, we explicitly encouraged participants to explore the

task, make errors, and learn from them as a group: “Test again and again whether the structure [participants had to build as part of task execution] is already stable enough (...). If the structure [collapses] - be happy because you made an error, and from your errors you can learn! Discuss in your group what went wrong. Be open about dealing with errors. This is the only way to learn from your errors. You can try around for 10 minutes - you even get [new constructions parts] every time! Thus, you can try out a variety of constructs. The more you try around, the more errors you will make - and the more errors you make, the better you can get!” (Note that all the groups had the chance to try again and were provided with new construction parts when the structure collapsed. This was clearly stated in the instructions. However, participants who received the error management culture manipulation based on error training instructions were explicitly encouraged to try around.)

In the *Error prevention culture* manipulation (*EPC*), participants were instructed to avoid errors while working on the team task, as they hinder them at work and because dealing with errors costs time and energy.

After receiving the manipulations and the instructions, participants were asked to discuss what they have read about errors and write down the most important points on a flipchart. By encouraging participants to discuss what they have read about errors and asking them to formulate action principles (e.g., Glaub, Frese, Fischer, & Hoppe, 2014), we aimed to foster internalization of our manipulations (Gal’perin, 1967). Participants then had 10 minutes to work on the first team task, the Marshmallow Challenge. Subsequently, participants individually had to complete questionnaires regarding how they perceived the work environment in the team. Afterwards, participants had to work on the second team task, the marble run task, for 10 minutes. Subsequently, participants individually had to complete questionnaires regarding how they perceived the work environment in the team during the second team task. Finally, participants were thanked, debriefed and compensated.

Measures

Manipulation check.

To assess whether our manipulations worked in the intended way, we counted the number of trials participants made until they arrived at their final solution in Task 1 and Task 2. The number of trials can be seen as errors made in the process, thus we expected teams in the error framing conditions “EMC-social influence” and “EMC-error exploration” to dare to make more errors than teams in the “EPC” condition. In line with our assumption, error framing condition (i.e., the manipulation participants received) had a significant main effect on the number of trials in the first task, $F(2,57) = 4.52, p < .05, \eta_p^2 = .14$. Participants who received the EPC manipulation tried significantly less times than participants who received the EMC-social influence manipulation, $t(57) = -2.80, p < .01, d = 0.88$ or participants who received the EMC-error exploration manipulation, $t(57) = -2.36, p < .05, d = 0.75$. There was no difference between teams in the two EMC conditions, $t(57) = 0.47, p = .64, d = 0.15$. For the second task, we did not find differences in the number of trials between error framing conditions, $F(2,57) = 1.72, p = .19, \eta_p^2 = .06$.

Dependent variables.

Team performance. As a measure of team performance in the first team task (Marshmallow Challenge), we measured the height of the spaghetti-structure (in cm) with the marshmallow on top. A requirement for measurement was that the structure does not collapse for 30 seconds. As a second measure, we coded whether the structure collapsed in 30 seconds or not (0 for collapsed, 1 for did not collapse). If the structure collapsed, team performance (i.e., the height of the structure) was rated with zero. As measures of team performance in the second team task (marble run task), we measured the height of the marble run (in cm), the number of pieces that were used to build the marble run, and how long the marble runs (in sec).

Error management culture (as perceived by the team). We assessed error management culture (as perceived by the team) with the 17-item Error Management Culture Questionnaire (van Dyck et al., 2005) with slight modifications of item wordings to fit the team context. A sample item is “After making a mistake, people in this team tried to analyze what had caused it”. The Error Management Culture Questionnaire (van Dyck et al., 2005) is commonly used as a measure in organizations (Frese & Keith, 2015). It entails aspects of error competence, learning from errors, analyzing errors, and error communication. Participants responded on a 5-point Likert scale. Cronbach's alpha was .89 for the first time of measurement (error management culture (as perceived by the team) during the Marshmallow Challenge) and $\alpha = .87$ for the second time of measurement (error management culture (as perceived by the team) during the marble run task).

Individual responses were aggregated at the team level. To justify aggregation, we computed within-team agreement for each team using $r_{wg(j)}$ (James, Demaree, & Wolf, 1984, 1993), and reliability of responses among team members with intraclass correlation coefficients (ICC; Bliese, 2000). For the first time of measurement, the mean values of $r_{wg(j)} = .83$, $ICC(1) = .27$ and $ICC(2) = .52$ ($F(59,120) = 2.11, p < .001$) suggested appropriate levels of within-team agreement and reliability (LeBreton & Senter, 2008), justifying aggregation. For the second time of measurement, the mean values of $r_{wg(j)} = .92$, $ICC(1) = .18$ and $ICC(2) = .39$ ($F(59,120) = 1.65, p < .05$) suggested appropriate levels of within-team agreement and reliability (LeBreton & Senter, 2008), justifying aggregation.

Control variables.

Error orientation. We included error orientation (measured before the manipulation) as control variable, because the success of our manipulations may depend on the participants' error orientation prior to taking part in our study. We assessed Error Orientation with the 37-item Error Orientation Questionnaire (Rybowiak, Garst, Frese, & Batinic, 1999). A sample

item is “Errors help me to improve my work”. Cronbach's alpha was .82.

Task familiarity. We included *task familiarity* as control variable, because performance in the “Marshmallow Challenge” task and in the marble run task may depend on how familiar participants are with similar tasks. We assessed task familiarity with the following two questions⁶: “Were you familiar with the “Marshmallow Challenge/marble run” task?”; “Have you worked on the “Marshmallow Challenge/marble run task” task before?” Cronbach's Alpha was .87 for the first task, and .79 for the second task.

Familiarity with team members. We assessed if participants were familiar with their team members by asking “How well do you know the two other members of your group?”. Participants responded on a 5-point Likert scale from 1 = not at all to 5 = extremely.

Results

Means, standard deviations, and correlations of study variables are depicted in Table 4.1 and 4.2.

⁶ We additionally assessed a third question “How familiar are you with tasks such as the Marshmallow Challenge/marble run task?” Due to poor reliability, this item was deleted from the scale.

Table 4.1
Means, Standard Deviations, and Intercorrelations of Study Variables

	<i>M</i>	<i>SD</i>	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Experimental Manipulation ¹																				
1. EMC 1 vs. others	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2. EMC 2 vs. others	-	-	-.50**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3. EPC vs. others	-	-	-.50**	-.50**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Manipulation check																				
4. Number of trials in Task 1	0.72	0.72	.23	.13	-.37**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5. Number of trials in Task 2	0.90	0.90	.12	.12	-.24	.27*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dependent Variable (team performance)																				
6. Height of the structure (Task 1)	21.07	21.63	-.03	.28*	-.25	.00	-.06	-	-	-	-	-	-	-	-	-	-	-	-	-
7. Did the structure collapse (Task 1)	-	-	-.02	.26*	-.24	.08	-.02	.86**	-	-	-	-	-	-	-	-	-	-	-	-
8. Height of the structure (Task 2)	34.95	7.91	-.16	.15	.01	.31*	.28*	-.18	-.06	-	-	-	-	-	-	-	-	-	-	-
9. Number of construction pieces (Task 2)	49.32	10.66	-.08	-.01	.09	.04	-.25	-.28*	-.18	.30*	-	-	-	-	-	-	-	-	-	-
10. Running time of marble (Task 2)	4.78	4.46	.19	.00	-.19	.10	-.17	.14	.18	-.13	.21	-	-	-	-	-	-	-	-	-
Additional Variables																				
11. EMC ² Task 1	3.62	0.51	.01	.36**	-.36**	-.18	-.07	.58**	.54**	-.23	-.15	.23	(.89)	-	-	-	-	-	-	-
12. EMC Task 2	4.10	0.36	.07	.16	-.23	-.23	-.03	.10	.03	-.17	.01	.20	.46**	(.87)	-	-	-	-	-	-
13. Culture strength ³ Task 1	0.83	0.29	.13	.13	-.26*	.04	.14	.03	.05	-.04	.22	.12	.31*	.13	-	-	-	-	-	-
14. Culture strength Task 2	0.92	0.18	.07	.00	-.07	-.24	-.01	.02	.00	-.11	.26*	.16	.02	.53**	.30*	-	-	-	-	-
15. Error orientation	3.75	0.23	.19	-.10	-.08	-.09	-.04	.08	-.03	-.05	-.24	-.07	.24	.25	-.11	-.18	(.82)	-	-	-
16. Task familiarity Task 1	1.85	0.26	.22	-.05	-.17	-.12	.00	.08	-.06	-.09	-.11	-.19	.04	.26*	.01	.13	.14	(.87)	-	-
17. Task familiarity Task 2	1.95	0.12	-.05	.11	-.05	.00	-.05	.20	.22	.23	.02	-.16	.25	.11	.06	-.03	.22	.15	(.79)	-
18. Familiarity with team members	4.24	0.89	.12	-.18	.06	-.13	-.11	-.04	-.14	-.13	.01	.05	-.06	-.14	-.16	-.04	-.10	.04	-.04	-

Note. *N* = 180 participants (60 teams). Cronbach's alphas are shown in parentheses along the diagonal. * $p < .05$. ** $p < .01$.

¹EMC 1 = Error Management Culture Manipulation based on normative social influence; EMC 2 = Error Management Culture Manipulation based on error management training instructions;

EPC = Error Prevention Culture Manipulation; ²EMC = Error management culture as perceived by the team; ³Culture strength was assessed as part of additional analyses and is therefore not listed under Measures. Variable EMC 1 vs. others was coded as 0 for EPC, 1 for EMC 1, and 0 for EMC 2. Variable EMC 2 vs. others was coded as 0 for EPC, 0 for EMC 1, and 2 for EMC 2. Variable EPC vs. others was coded as 1 for EPC, 0 for EMC 1, and 0 for EMC 2. Did the structure collapse was coded 0 for collapsed and 1 for did not collapse.

Table 4.2
Means and Standard Deviations of Main Variables by Between-Participants Factor Levels¹

Error framing condition ¹	EPC (N = 60 in 20 triads)		EMC 1 (N = 60 in 20 triads)		EMC 2 (N = 60 in 20 triads)	
	M	SD	M	SD	M	SD
Team performance in Task 1						
Height of the structure	13.38	18.51	20.18	20.78	29.66	23.18
Did the structure collapse	12x did collapse, 8x did not		9x did collapse, 11x did not		5x did collapse, 15x did not	
Team performance in Task 2						
Height of the structure	35.05	6.89	33.15	8.45	36.65	8.30
Number of construction pieces	50.65	11.51	48.15	10.66	49.15	10.15
Running time of marble	3.62	2.81	5.98	6.45	4.75	3.06
EMC ² Task 1	3.36	0.37	3.63	0.52	3.88	0.51
EMC Task 2	3.98	0.25	4.14	0.36	4.19	0.44
Number of trials in Task 1	0.35	0.67	0.95	0.69	0.85	0.67
Number of trials in Task 2	0.60	0.68	1.05	0.94	1.05	1.00

¹Error framing condition: Error prevention culture manipulation (EPC) vs. Error management manipulation based on normative social influence (EMC 1) vs. error management manipulation based on error management training instructions (EMC 2).

²EMC = error management culture as perceived by the team.

Preliminary Analyses

To test whether participants' error orientation, task familiarity (with the first or second task), and familiarity with team members differed between conditions, we conducted univariate ANOVAs. Participants' error orientation ($F(2,57) = 1.04, p = .36, \eta_p^2 = .04$), task familiarity with the Marshmallow Challenge ($F(2,57) = 1.59, p = .21, \eta_p^2 = .05$), task familiarity with the marble run task ($F(2,54) = 0.30, p = .74, \eta_p^2 = .01$), and familiarity with team members ($F(2,57) = 0.96, p = .39, \eta_p^2 = .03$) did not differ between conditions. Thus, control variables were excluded from further analyses.

Hypotheses Testing

Conceptual hypothesis.

Our conceptual hypothesis assumed that error management culture predicts team performance. To test this hypothesis, we conducted linear regression analysis with error management culture (as perceived by the team) as predictor variable and our first team performance measure in the Marshmallow Challenge, namely the height of the structure, as criterion variable. The results of the linear regression analysis indicated that error management culture (as perceived by the team) explained a significant proportion of variance in team performance scores, $R^2 = .34, F(1,58) = 29.51, p < .001$. Furthermore, error management culture (as perceived by the team) significantly predicted team performance, $b = 24.74, (\beta = .58), t(58) = 5.43, p < .001$.

To test our conceptual hypothesis for our second team performance measure in the Marshmallow Challenge, namely whether the structure collapsed or not, we conducted logistic regression analysis. The results of the logistic regression analysis indicated that error management culture (as perceived by the team) explained a significant proportion of variance in team performance scores, $R^2 = .39, \chi^2(1) = 20.60, p < .001$. Furthermore, error management

culture (as perceived by the team) significantly predicted team performance, $b = 3.09$ ($SE = .086$), $p < .001$, $Odds\ Ratio = 22.04$.

Operational hypothesis.

Our operational hypothesis assumed that an error management culture manipulation (Ha: based on normative social influence, and Hb: based on error management training instructions) fosters error management culture (as perceived by the team), and thus performance. To test this hypothesis, we first conducted a univariate ANOVA. We found a significant main effect of error framing condition on error management culture (as perceived by the team), $F(1,57) = 6.04$, $p < .01$, $\eta_p^2 = .18$ (see Figure 4.2, Panel a).

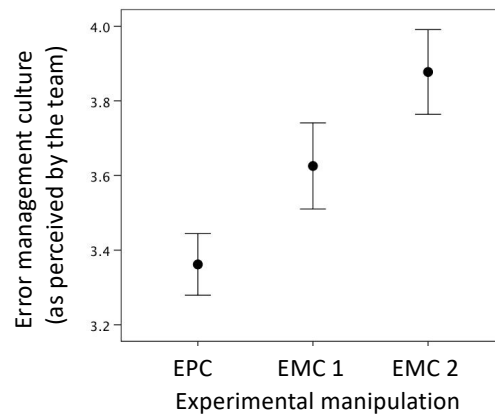
Planned pairwise-comparisons revealed that teams manipulated with EMC-error exploration perceived significantly higher levels of error management culture than teams that received an EPC manipulation, $t(38) = 3.67$, $p < .01$, $d = 0.86$. Teams manipulated with EMC-social influence did not perceive significantly higher levels of error management culture than teams that received an EPC manipulation, $t(38) = 1.86$, $p = .07$, $d = 0.59$. We found no difference in teams' perception of error management culture between EMC conditions, $t(38) = 1.56$, $p = .13$, $d = 0.49$. In sum we were able to induce error management culture (as perceived by the team) in teams with an error management culture manipulation. However, only the EMC-error exploration manipulation affected teams' perception of error management culture, but not the EMC-social influence manipulation.

Additionally, we tested whether team performance differed between error framing conditions (i.e., experimental manipulations). We conducted a univariate ANOVA with error framing condition as predictor and our first measure of team performance in the Marshmallow challenge, the height of the structure as criterion variable. We did not find a significant main effect of error framing condition on team performance, $F(2,57) = 3.06$, $p = .05$, $\eta_p^2 = .10$. However, planned pairwise comparisons revealed that teams manipulated with an EMC-error

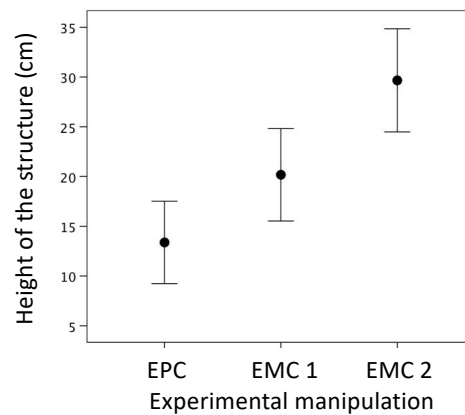
exploration manipulation had significantly higher performance scores than teams that received an EPC manipulation, $t(38) = 2.46, p < .05, d = 0.78$. Teams manipulated with EMC-social influence did not have significantly higher performance scores than teams that received an EPC manipulation, $t(38) = 1.09, p = .28, d = 0.35$. We found no difference in teams' performance between teams manipulated with EMC manipulations, $t(38) = 1.36, p = .18, d = 0.43$ (see Figure 4.2, Panel b).

For our second team performance measure in the Marshmallow Challenge, namely whether the structure collapsed or not, we conducted logistic regression analysis. Due to the multicategorical nature of our predictor variable error framing condition, we created two dummy variables with indicator coding and the error prevention culture manipulation as reference category: D1 with codes of (0, 1, (0)) and D2 with codes of (0, (0), 1) for EPC manipulation, for EMC-error exploration, and EMC-social influence, respectively. We found that D1 (EMC-error exploration vs. EPC) significantly predicted team performance, $b = 1.50$ ($SE = 0.69$), $p < .05$, $Odds\ Ratio = 4.50$; $R^2 = .11$, $\chi^2(2) = 5.17, p = .07$. D2 (EMC-social influence vs. EPC) did not predict team performance, $b = 0.61$ ($SE = 0.64$), $p = .34$, $Odds\ Ratio = 1.83$ (see Figure 4.2, Panel c).

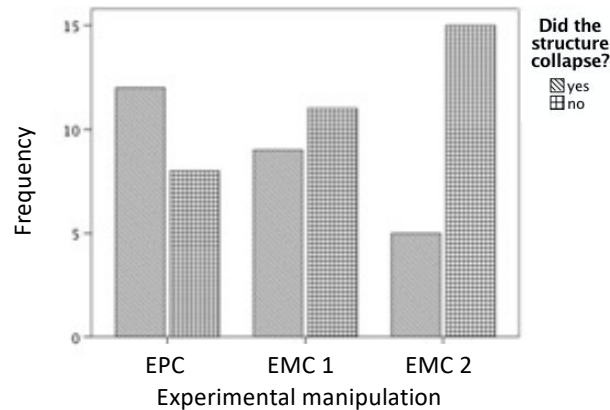
In sum, we found evidence that teams manipulated with an error management culture manipulation had higher team performance in Task 1 (Marshmallow Challenge: higher structures and less structure-collapses) than teams manipulated with error prevention culture manipulations. However, only teams that received the EMC-error exploration manipulation had higher team performance, but not teams that received the EMC-social influence manipulation.



(a) Differences in error management culture (as perceived by the team) (Task 1) between experimental manipulation groups ($M \pm 1 SE$)



(b) Differences in team performance (Task 1) between experimental manipulation groups ($M \pm 1 SE$)



(c) Differences in team performance (Task 1) between experimental manipulation groups ($M \pm 1 SE$)

Figure 4.2. Differences in error management culture (as perceived by the team) and team performance (Task 1) between experimental manipulation groups ($M \pm 1 SE$). EPC = Error prevention culture manipulation; EMC 1 = Error management culture manipulation based on normative social influence; EMC 2 = Error management culture manipulation based on error management training instructions.

Second, we conducted mediation analyses (Preacher & Hayes, 2004; Hayes & Preacher, 2014) with error framing condition (i.e., error management culture manipulation based on error training instructions, error management culture manipulation based on normative social influence, and error prevention culture manipulation) as predictor variable, error management culture (as perceived by the team) as mediator variable, and team performance in the first team task (height of the structure or did the structure collapse or not) as criterion variable. We used 5,000 bootstrap samples and estimated 95 % bootstrap confidence intervals (CI). If the CI does not include zero, mediation is supported. For our multicategorical predictor variable (i.e., error framing condition), we used the same dummy variables as in previous analysis. We found the significant indirect effect for our dummy variable “EMC-error exploration vs. EPC” (D1) $b = 12.02$, CI [4.76, 21.05], but not for our dummy variable “EMC-social influence vs. EPC” (D2), $b = 6.14$, CI [-0.43, 14.67] (see Figure 4.3).

Furthermore, we found support for the indirect effect of error framing condition on team performance for our second team performance measure in the Marshmallow Challenge (did the structure collapse or not) through error management culture (as perceived by the team) for our dummy variable “EMC-error exploration vs. EPC” (D1) $b = 1.57$, CI [0.60, 3.55], but not for our dummy variable “EMC-social influence vs EPC” (D2), $b = 0.80$, CI [-0.08, 1.38] (see Figure 4.4). In sum, error management culture (as perceived by the team) mediates the relationship between error framing condition (i.e., the manipulation the teams received) and team performance.

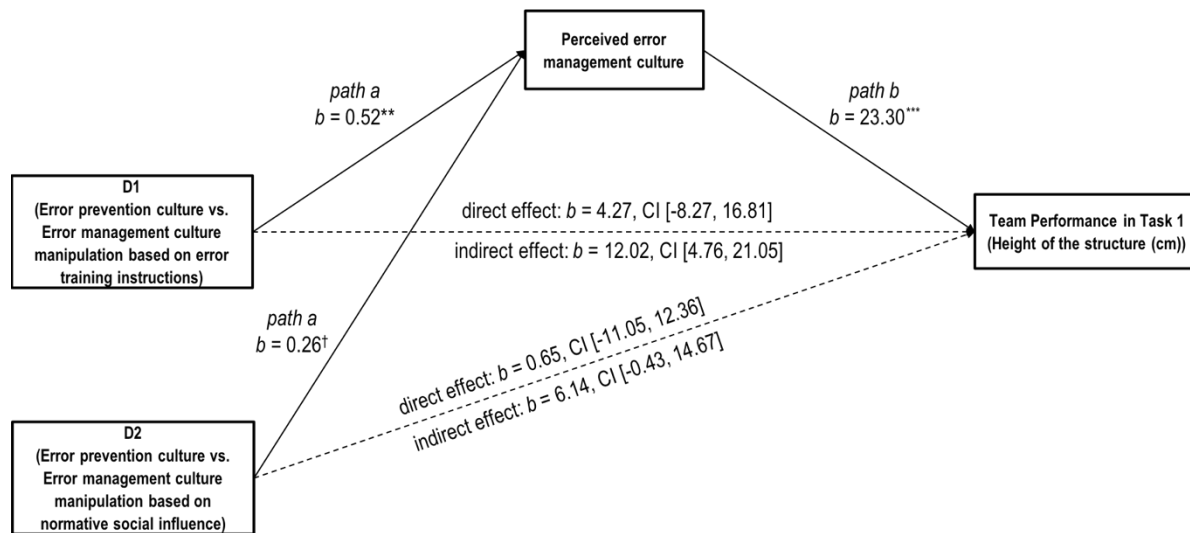


Figure 4.3. The significant indirect effect of dummy variable D1 for our manipulation (i.e., error prevention culture manipulation (coded 0) vs. error management culture manipulation based on error training instructions exploration (coded 1)), and the non-significant indirect effect of dummy variable D2 for our manipulation (i.e., error prevention culture (coded 0) vs. error management culture manipulation based on normative social influence (coded 1)) on team performance (first indicator) in Task 1 through error management culture (as perceived by the team). Team Performance: Height of the structure in cm. Higher values indicate better performance. The dashed arrows indicate the direct paths between the dummy variables for our manipulation (D1, and D2) and team performance. Unstandardized values and confidence intervals (CI). $N = 180$ participants (60 teams). $^{\dagger} p < .10$, $^{**} p < .01$, $^{***} p < .001$.

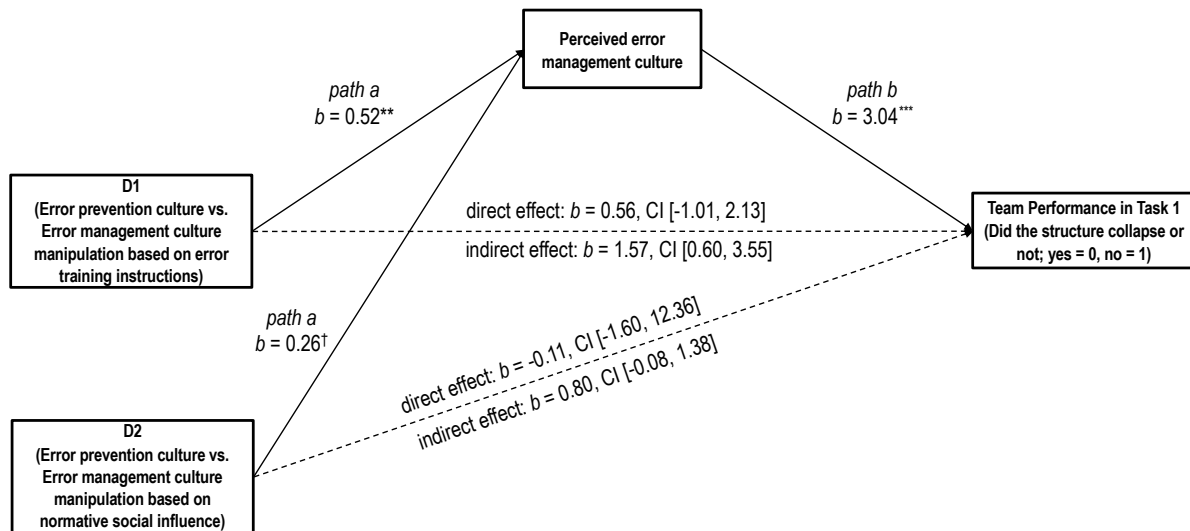


Figure 4.4. The significant indirect effect of dummy variable D1 for our manipulation (i.e., error prevention culture manipulation (coded 0) vs. error management culture manipulation based on error training instructions exploration (coded 1)), and the non-significant indirect effect of dummy variable D2 for our manipulation (i.e., error prevention culture (coded 0) vs. error management culture manipulation based on normative social influence (coded 1)) on team performance (second indicator) in Task 1 through error management culture (as perceived by the team). Team Performance: did the structure collapse (0) or not (1). The dashed arrows indicate the direct paths between the dummy variables for our manipulation (D1, and D2) and team performance. Unstandardized values and confidence intervals (CI). $N = 180$ participants (60 teams). $^{\dagger} p < .10$, $^{**} p < .01$, $^{***} p < .001$.

Open Research Question Testing

Our open research question asked whether the effects of error management culture manipulations on error management culture (as perceived by the team) and thus on team performance persist over time. We tested our open research question first using a univariate ANOVA with error framing condition (error management culture manipulation based on error training instructions, error management culture manipulation based on normative social influence, and error prevention culture manipulation) as predictor variable and error management culture (as perceived by the team) during the second task (marble run task) as criterion variable. Teams' perception of error management culture during the second team task did not differ between error framing conditions (i.e., which manipulation the teams received), $F(2,57) = 1.72, p = .19, \eta_p^2 = .06$.

Second, we conducted multivariate regression analysis to test the relationship of error management culture (as perceived by the team) and team performance in the second task. We found no relationship between error management culture (as perceived by the team) and team performance in the second task (indicators: height of the marble run, the number of pieces that were used to build the marble run, and running time of the marble), $F(3,56) = 1.19, p = .32, \eta_p^2 = .06$. Post-hoc univariate test-results are depicted in Table 4.3.

Furthermore, we conducted a multivariate ANOVA with error framing condition (EMC-error exploration, EMC-social influence, and EPC manipulation) as predictor variable and team performance in the second team task (indicators: height of the marble run, the number of pieces that were used to build the marble run, and running time of the marble) as criterion variable. The multivariate test results did not show a main effect of error framing condition on team performance in the second team task, $F(6,112) = 0.95, p = .46, \eta_p^2 = .05$.

As we did not find an effect of error framing condition (i.e., experimental manipulation) neither on error management culture (as perceived by the team), nor on team performance, we

did not proceed with mediation analysis. In sum, the effects of an error management culture manipulation on error management culture (as perceived by the team) and thus team performance did not persist over time.

Table 4.3

Univariate Test Results of the Multivariate Regression Analysis

Criterion variable	Predictor	<i>b</i>	<i>SE(b)</i>	β	<i>t</i>	<i>p</i>	η_p^2
Height of the structure ¹	Error management culture ⁴	-3.67	2.83	-0.17	-1.30	.20	.03
Number of construction pieces ²	Error management culture	0.30	3.86	0.01	0.08	.94	.00
Running time of marble ³	Error management culture	2.44	1.59	0.20	1.54	.13	.04

Notes. *N* = 180 participants (60 teams).

¹ $R^2 = .03$; ² $R^2 = .00$; ³ $R^2 = .04$; ⁴ as perceived by the team.

Additional Exploratory Analyses

One potential explanation for our results that our manipulations of error management culture only resulted in higher error management culture perceptions and team performance in the first but not in the second task is that we did not actually succeed in establishing a culture. It may be that our results in the first task are only indicators of participants' superficial compliance with the instructions. (In our Discussion section, we discuss further alternative explanations for these results.) Schneider, Salvaggio, and Subirats (2002) suggest “that the continuity over time of a climate or a culture will be a function of the strength of climate or culture” (p. 227). The authors conceptualize climate or culture strength as the degree of within-group agreement about climate or culture (Schneider et al., 2002; Schneider, Ehrhart, & Macey, 2013). They propose that “in weak climate conditions, regardless of the level of the climate perceptions, predictions of behavior would be less reliable than when the climate is strong” (Schneider et al., 2002, p. 221). Following this argumentation, it may be possible that the reason we did not find results for our second task is because some groups had weaker culture or climate strength. Thus, culture or climate strength shall moderate the relationship of error management culture (as perceived by the team) and team performance in the second task (Schneider et al., 2002, p. 221; Gonzáles-Romá, Peiró, & Tordera, 2002). That is, in groups with high culture or

climate strength, error management culture (as perceived by the team) should predict team performance.

To test this assumption, we conducted multivariate multiple regression analysis with culture or climate strength (Task 2) as moderator, error management culture (as perceived by the team) as predictor, and team performance in the second task as criterion variable (indicators: height of the marble run, the number of pieces that were used to build the marble run, and running time of the marble). We operationalized culture or climate strength using $r_{wg(j)}$ (James et al., 1984, 1993). Culture or climate strength was mean-centered and included as a between-participants covariate (Cohen, Cohen, West, & Aiken, 2003). We did not find a main effect of culture or climate strength, $F(3,54) = 0.27, p = .85, \eta_p^2 = .01.$, nor an interaction effect of error management culture (as perceived by the team) and culture or climate strength on team performance in the second task, $F(3,54) = 0.22, p = .88, \eta_p^2 = .01.$ ⁷ Results of additional post-hoc univariate analyses are depicted in Table 4.4.

⁷ We also tested the assumed moderator role of culture or climate strength for our first task using multiple linear regression and multiple logistic regression analyses. Culture or climate strength did not predict team performance, $b = 56.88, (\beta = .75) t(58) = 0.51, p = .61$, nor did we find an interaction effect of error management culture (as perceived by the team) and culture or climate strength on the first indicator (height of the structure) of team performance in Task 1, $b = -21.00, (\beta = -.93), t(58) = -0.62, p = .54$; Model: $R^2 = .36, F(3,56) = 10.72, p < .001$. Furthermore, culture or climate strength did not predict the second indicator (did the tower collapse) of team performance, $b = 25.66 (SE = 27.15), p = .35, Odds Ratio = 1.39$, nor did we find an interaction effect of error management culture (as perceived by the team) and culture or climate strength on team performance, $b = -8.38 (SE = 8.46), p = .32, Odds Ratio = 0.00$; Model: $R^2 = .43 \chi^2(1) = 23.50, p < .001$.

Table 4.4
Univariate Test Results of the Multivariate Multiple Regression Analysis

Criterion variable	Predictor	<i>b</i>	<i>SE(b)</i>	β	<i>t</i>	<i>p</i>	η_p^2
Height of the structure ¹	Error management culture ⁴	-3.43	3.39	-0.16	-1.01	.32	.02
	Culture/climate strength	-25.30	46.02	-0.58	-0.55	.58	.01
	Error management culture X Culture/climate strength	7.21	13.70	0.06	0.53	.60	.00
Number of construction pieces ²	Error management culture	-5.30	4.43	-0.18	-1.20	.24	.02
	Culture/climate strength	7.56	60.12	0.13	0.13	.90	.00
	Error management culture X Culture/climate strength	4.05	17.90	0.23	0.23	.82	.00
Running time of marble ³	Error management culture	1.88	1.90	0.15	0.99	.33	.02
	Culture/climate strength	-12.74	25.76	-0.51	-0.49	.62	.00
	Error management culture X Culture/climate strength	4.39	7.67	0.60	0.57	.57	.01

Notes. *N* = 180 participants (60 teams).

¹ $R^2 = .03$; ² $R^2 = .09$; ³ $R^2 = .05$; ⁴ as perceived by the team

We additionally reran all analyses for the open research question without the groups that had low within-group agreement. One option researchers mention when both low and high levels of agreement groups are within a single data set is to eliminate low-agreement groups (LeBreton & Senter, 2008; Biemann, Cole, & Voelpel, 2012; Burke, Cohen, Doveh, & Smith-Crowe, 2018; e.g., Susskind, Kacmar, & Borchgrevink, 2003; Aryee, Chen, & Budhwar, 2004; Riordan, Vandenberg, & Richardson, 2005). Nevertheless, LeBreton and Senter (2008) and Biemann and colleagues (2012) warn about deleting low-agreement groups prior to hypothesis testing “because losing valuable data points is never ideal [and] statistical power will be reduced” (Biemann et al., 2012; p. 74). However, Biemann and colleagues (2012) also suggest that conducting analyses with and without low-agreement groups is a viable option. We followed this recommendation and reran analyses for the second team task without low-agreement groups (e.g., Shaw, Zhu, Duffy, Scott, Shih, & Susanto, 2011). We eliminated groups based on $r_{wg(j)}$ -values (James et al., 1984, 1993) and the standard deviation of

participants' perceptions of error management culture (Schneider et al., 2002). We eliminated two groups that had low $r_{wg(j)}$ -values and also high standard deviations. Afterwards, we reran all analyses for our open research question⁸.

First, we reran the univariate ANOVA with error framing condition (i.e., which manipulation the teams received) as predictor variable and error management culture (as perceived by the team) during the second task (marble run task) as criterion variable. We did not find a main effect of error framing condition (i.e., which manipulation the teams received) on error management culture (as perceived by the team), $F(2,55) = 3.15$, $p = .05$, $\eta_p^2 = .10$ (Figure 4.5).

However, planned pairwise-comparisons revealed that teams manipulated with EMC-error exploration perceived significantly higher levels of error management culture than teams that received an EPC manipulation, $t(36) = 2.74$, $p < .01$, $d = 0.89$. Teams manipulated with EMC-social influence did not perceive higher levels of error management culture than teams that received an EPC manipulation, $t(37) = 1.37$, $p = .18$, $d = 0.44$. We found no difference in teams' perception of error management culture between EMC conditions, $t(37) = 1.09$, $p = .28$, $d = 0.35$. In sum, we found the same pattern of results as for the first team task: teams' perception of error management culture was highest when they received an error management culture manipulation based on error training instructions.

Additionally, we conducted a multivariate ANOVA with error framing condition (EMC-error exploration, EMC-social influence, and EPC manipulation) as predictor variable and team performance in the second team task (indicators: height of the marble run, the number of pieces that were used to build the marble run, and running time of the marble). The multivariate test results did not show a main effect of error framing condition on team

⁸ For Task 1 we repeated this procedure. We eliminated three groups that had low $r_{wg(j)}$ -values and also high standard deviations. We reran all analyses. The effect of the dummy variable for error framing condition D1 (EMC-error exploration vs. EPC) changed from $b = 1.50$ ($SE = 0.69$), $p < .05$, *Odds Ratio* = 4.50 to $b = 1.32$ ($SE = 0.70$), $p = .06$, *Odds Ratio* = 3.75. Other results remained unaltered.

performance in the second team task, $F(6,108) = 0.89, p = .51, \eta_p^2 = .05$.

Second, we reran the multivariate regression analysis to test the relationship of error management culture (as perceived by the team) and team performance in the second task. We found no relationship between error management culture (as perceived by the team) and team performance in the second task (indicators: height of the marble run, the number of pieces that were used to build the marble run, and running time of the marble), $F(3,54) = 0.74, p = .53, \eta_p^2 = .04$. Post-hoc univariate test-results are depicted in Table 4.5.

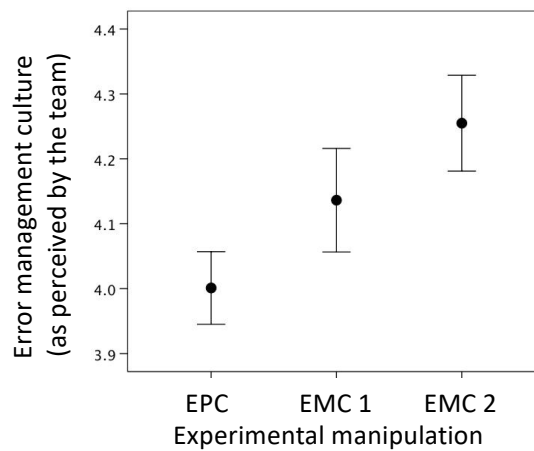


Figure 4.5. Differences in error management culture (as perceived by the team) (Task 2) between experimental manipulation groups ($M \pm 1 SE$). EPC = Error prevention culture manipulation; EMC 1 = Error management culture manipulation based on normative social influence; EMC 2 = Error management culture manipulation based on error management training instructions.

Table 4.5

Univariate Test Results of the Multivariate Regression Analysis after Eliminating two Teams

Criterion variable	Predictor	<i>b</i>	<i>SE(b)</i>	β	<i>t</i>	<i>p</i>	η_p^2
Height of the structure ¹	Error management culture ⁴	-2.97	3.24	-0.12	-0.92	.36	.01
Number of construction pieces ²	Error management culture	-3.67	4.24	-0.12	-0.86	.39	.01
Running time of marble ³	Error management culture	1.77	1.82	0.13	0.97	.33	.02

Notes. $N = 174$ participants (58 teams).

¹ $R^2 = .02$; ² $R^2 = .01$; ³ $R^2 = .02$; ⁴ as perceived by the team.

Third, we conducted the same multivariate multiple regression analysis with culture/climate strength as moderator, error management culture (as perceived by the team) as predictor, and team performance (in the second team task) as criterion variable. We found a main effect of culture or climate strength, $F(3,52) = 4.43, p < .01, \eta_p^2 = .20$, and an interaction effect of error management culture (as perceived by the team) and culture or climate strength on team performance in the second task, $F(3,52) = 4.09, p < .05, \eta_p^2 = .19$. Results of additional post-hoc univariate analyses are depicted in Table 4.6. We found the expected interaction effect of error management culture (as perceived by the team) and culture or climate strength only for one indicator of team performance in the second team task, the running time of the marble (Figure 4.6).

Additionally, we conducted moderated mediation analysis with PROCESS (Model 14; Preacher & Hayes, 2004; Hayes & Preacher, 2014), with error framing condition as predictor, team performance in Task 2 (only the indicator running time of marble) as criterion variable, error management culture (as perceived by the team) as mediator, and culture or climate strength as moderator of the relationship error management culture (as perceived by the team) and team performance in Task 2. The index of the moderated mediation was not significant, D1: Index = 25.00, CI [-10.63, 59.75]; D2: Index = 13.32, CI [-9.07, 46.54].

In sum, the results imply that the effects of an error management culture manipulation on error management culture (as perceived by the team) and on team performance did persist over time – however, only when culture strength was high.

Table 4.6

Univariate Test Results of the Multivariate Multiple Regression Analysis after Eliminating two Teams

Criterion variable	Predictor	<i>b</i>	<i>SE(b)</i>	β	<i>t</i>	<i>p</i>	η_p^2
Height of the structure ¹	Error management culture ⁴	2.53	4.78	0.10	0.53	.60	.01
	Culture/climate strength	231.68	208.30	1.49	1.11	.27	.02
	Error management culture X Culture/climate strength	-70.31	57.13	-1.73	-1.23	.22	.03
Number of construction pieces ²	Error management culture	-3.67	6.40	-0.11	-0.57	.57	.01
	Culture/climate strength	-0.30	278.84	-0.00	-0.00	.99	.00
	Error management culture X Culture/climate strength	0.08	76.47	0.00	0.00	.99	.00
Running time of marble ³	Error management culture	-2.08	2.43	-0.15	-0.86	.40	.01
	Culture/climate strength	-380.73	106.05	-4.37	-3.59	.00	.19
	Error management culture X Culture/climate strength	99.38	29.08	4.35	3.42	.00	.18

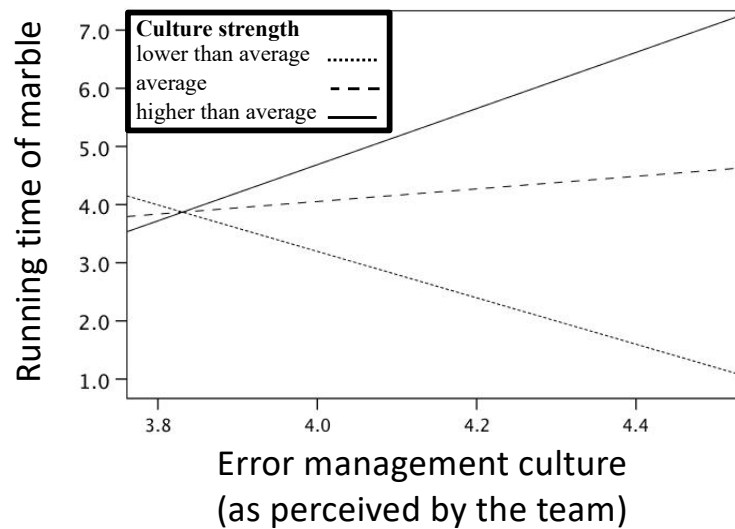
Notes. *N* = 174 participants (58 teams).¹*R*² = .06; ²*R*² = .01; ³*R*² = .23; ⁴ as perceived by the team

Figure 4.6. Interaction effect of error management culture (as perceived by the team) and culture strength on team performance in Task 2.

Discussion

Error management culture is a popular concept that many organizations adopt. Field studies have shown beneficial effects of error management culture on performance. However, experimental evidence on how to induce an error management culture, and whether the error management culture–performance relationship can also be observed under standardized conditions, was lacking. In the present study, we successfully manipulated (a) error management culture (as perceived by the team) in teams by fostering exploration (i.e., with a manipulation that is based on error management training instructions), (b) partially replicated the beneficial effect of error management culture on team performance in creative problem-solving tasks, and (c) showed that inducing an error management culture in teams by fostering exploration can increase performance in a creative problem-solving task. However, (d) the effects of our manipulation on error management culture (as perceived by the team) and team performance persisted over time only when culture strength (i.e., the agreement between groups members about the culture) was high. In the following, we will discuss our findings in greater detail.

Theoretical Contributions

From a theoretical perspective, we contribute to the literature on error management culture and organizational culture by examining error management culture under experimental conditions. In our study, we managed to affect participants' common perception of error management culture with manipulations based on error training instructions, even though, unlike in traditional teams, participants in our study had not known each other before, did not share a common culture, and interacted only for a rather short period of time (approximately 10-20 minutes). In organizations, the organizational culture is presumably engrained and internalized by the members of the organization. On the contrary, in our study, culture had to be newly established. Regardless of the short time period of our study, our manipulation of

error management culture based on error training instructions affected participants' common perception of the groups' error culture (i.e., error management culture) and even team performance in the first task, which is striking. Our results are in line with the findings of error management training research (e.g., Keith & Frese, 2005, 2008). Error management training research found error management training instructions that foster exploration to increase individuals' task performance (e.g., Keith & Frese, 2005, 2008).

However, the question remains why our second error management manipulation that was based on normative social influence did not foster error management culture (as perceived by the team) and performance. This can be for the following reasons. First, the social impact theory (Latané, 1981) postulates three factors that determine the effectiveness of normative social influence or whether participants conform to group norms: (a) strength, (b) immediacy, and (c) number. Strength is defined as “the salience, power, importance, or intensity of a given source to the target” (Latané, 1981, p. 344), which is determined by factors such as the source's age, economic status, or intellect. Immediacy is the “closeness in space or time and absence of intervening barriers or filters” (Latané, 1981, p. 344). Number stands for the number of group members that are potential influence sources. The higher the strength, immediacy and number of group members is, the more people will conform to group norms. However, the number of group members only affects conformity to a certain point: conformity to norms does not increase anymore when groups have more than three to five people (e.g., Asch, 1955; Bond, 2005). While two factors, number and immediacy, apply to the teams in our study as they were face to face and consisted of three members, strength (i.e., personal importance) may not apply to our teams. It can be argued whether a team formed for experimental purposes will be considered important for team members. It is also debatable whether the external source of the norm that shall be internalized was seen as important by team members in our study.

Second, task importance can also affect conformity to group norms (Baron, Vandello,

& Brunzman, 1996). Whether and how important participants perceive a task in an experimental situation is questionable. Third, it is possible that normative social influence is more effective when only one particular and precise behavior pattern is communicated as group norm that is easy to implement (e.g., reusing the towels as previous guests did helps to save the environment; Goldstein et al., 2008). However, it could be that the error management manipulation that was based on normative social influence did have an effect on error management culture (as perceived by the team), but the effect was not strong enough to be statistically significant. Descriptively, the results (see Figure 4.2, Panel a) indicate that this manipulation did have a weak effect on teams' perception of error management culture.

It also has to be noted that while we managed to affect participants common perception of error management culture in their teams with a manipulation based on error management training instructions and thus foster team performance in the first team task (Marshmallow Challenge), the results for the second team task (marble run task) remained only partially stable. Teams' perception of error management culture and team performance in the second team task differed between experimental conditions (i.e., manipulations) only when culture strength was high. A potential explanation for this result is that the effect of our error management culture manipulation on error management culture (as perceived by the team) in the first team task was only an indicator of a superficial compliance with the instructions rather than an indicator of actual change in attitudes towards errors or culture. However, this would contradict the results we found while testing for the potential moderator effect of culture or climate strength (Schneider et al., 2002; Gonzáles-Romá et al., 2002). We did find an interaction effect of error management culture (as perceived by the team) and culture strength on one of our performance-indicators in Task 2, namely the running time of the marble. This is in line with the suggestion of Schneider and colleagues (2002) that “the commonly held assumption that climates (and cultures) persist over time (e.g., Schein, 1992) must be modified

to say strong climates (and cultures) persist over time” (p. 227). Another explanation for our results may lie in the nature of our teams. As mentioned above, the teams in our study were newly formed of people who did not interact prior to task engagement, thus did not have a common culture. Consequently, unlike in traditional teams, the groups' culture had to be newly formed and unfold. It is possible that our manipulation of error management culture was not strong enough to impact participants' perception of error management culture, and thus team performance in the long term. Also, the interactive approach to the etiology of culture sees the formation of culture as an interactive learning process between members (Ashforth, 1985; Moran & Volkwein, 1992). It is questionable whether participants have enough possibilities to interact and learn in a short-term study like ours.

Furthermore, it is debatable whether a strong change will take place in response to external influences, such as our manipulations, or whether the interaction and learning processes of group members are more important. However, several authors stressed the important role of the group's former (in our case the role of the experimenter), that is, the external influence in the formation and change process (e.g., Schein, 1983, Gagliardi, 1986). Moreover, in their study, Gonzáles-Romá and colleagues (2002) found that leaders' informing behavior positively correlates with culture or climate strength. Furthermore, van Dyck, Dimitrova, de Korne, and Hiddema (2013) found that the leaders' active reinforcement of priority of safety promotes error management. Bligh, Kohles, and Yan (2018) suggest that especially the transformational leadership style fosters attitudes towards error learning. Whether participants actually considered the experimenter as the founder or leader of the group in our study and thus, whether the founder's beliefs, and values were of importance for the group may be an issue.

In sum, our results indicate that it is more difficult to induce error management culture in teams than we thought. This is somewhat surprising considering how quick group norms can

form according to social psychology. For example, in Sherif's (1935; 1936) conformity or autokinetic experiments, groups quickly developed a group norm and also behaved according to it. Tajfel's minimal group paradigm (1970) also suggests that developing common perception or assumptions is a quick process. Even in excessive minimal group conditions participants almost immediately favor the own group and discriminate others, which indicates that some shared perception establishes quite quickly.

Our finding that error management culture was positively related to team performance in a creative problem solving task (note that in the second team task only when culture strength was high and only for one indicator of team performance) is consistent with the findings of previous research in organizations (e.g., Fischer et al., 2018; van Dyck et al., 2005) that indicate that error management culture is beneficial for performance-related outcomes. In this respect, the present research can be seen as an experimental replication of previous correlational field studies. Nonetheless, our experiment should not only be considered as a replication of previous results, but as complementary to previous correlational research for the following reasons.

First, as noted above, field studies have the advantage of high ecological validity, which may come at the expense of internal validity. By investigating error management culture experimentally under standardized conditions, it is possible to account for confounding factors that can hardly be avoided in field research. In organizations, several confounding factors could influence organizational performance, other than error management culture, which leaves the question of causality unanswered (Shadish, Cook, & Campbell, 2002). Second, previous field studies have mainly investigated “traditional” organizations (and teams), where a common view on errors is most likely engrained. However, teams newly form and change frequently. Furthermore, in recent years, an increasing amount of work is conducted outside traditional organizational structures. Many teams are formed for a specific purpose or interact only for the duration of the task. In such teams, shared norms and practices regarding errors are not yet

established. Our study investigated such teams and showed that even newly formed teams can benefit from the favorable effects error management culture.

Strengths, Limitations, and Directions for Future Research

One strength of our study is that we used different sources for our variables, this way eliminating the common source bias, which is a common problem in many studies. Error management culture (as perceived by the team) was an aggregate measure of the respective team members. Our dependent variable, task performance, (e.g., height of the structure in the Marshmallow challenge), was an objective rating measure.

Another strength of our study is that participants worked on actual tasks that required creative problem-solving, namely the Marshmallow challenge and the marble run task. This way, we were able to complement advantages of an experimental setting, such as standardization, with advantages of field studies, such as task engagement. We hope that this way, we were able to contribute to generalizability and high applicability of our results. However, we encourage future studies to investigate whether error management culture is also beneficial for different tasks, for example, tasks that require rational problem-solving instead of creative problem-solving.

Rational problem-solving tasks presumably require a greater extent of convergent thinking, while creative problem-solving tasks require a greater extent of divergent thinking. Convergent thinking is considered as a type of thinking that focuses on generating one possible conclusion, a single correct answer to a clearly defined problem (Guilford, 1957). “Thinking is channeled or controlled in the direction of that answer” (Guilford, 1957, p. 274). In contrast, in divergent thinking, “there is much searching or going off in various directions” (Guilford, 1957, p. 274). There are multiple possible solutions to an open-ended problem (Guilford, 1957). An example for divergent thinking is brainstorming. Divergent thinking can easily be

associated with making errors as part of idea generation. Thus, an environment that does not punish errors (i.e., error management culture) may facilitate divergent thinking and finding a solution to a creative problem-solving task. Convergent thinking uses a more controlled, logical approach that may not allow the occurrence of errors in the process of idea-generation in rational problem-solving tasks. Moreover, the errors made in the process may not even be visible. However, despite best efforts, errors will prevail (e.g., Reason, 1997; Zhao & Olivera, 2006). We thus assume that error management culture will also be beneficial for performance in rational problem-solving tasks by fostering open communication and an environment where errors are not punished.

Furthermore, in our tasks, participants could clearly see and know when they made an error (i.e., the structure collapsed). The tasks themselves provided feedback that someone has made an error. Future studies may investigate if making an error and receiving feedback is necessary for error management culture to unfold its beneficial effects on performance. Possibly, it may even be enough to have an environment where errors are considered as chances to learn rather than as threats (e.g., an error management culture) to improve performance.

Another strength of our study is that teams in our experiment were newly formed, thus did not have an already established error (management) culture. Field studies have the advantage to investigate traditional teams which have an already established error (management) culture and thus change processes. Newly formed teams in our experiment allowed us to investigate whether it is even possible to establish an error management culture at all. Furthermore, conducting our study with newly formed teams allowed us to ascribe the results regarding error management culture (as perceived by the team) and team performance to our manipulations and not to the teams' previously established error (management) culture.

Moreover, in research, replication is “a viable antidote to what Bliese and Wang (2019) term ‘origination bias,’ or in other words, ‘the practice of viewing findings from a single,

original study as being almost sacred,’ even if these findings were exploratory in nature” (Bamberger, 2019, p. 104). Thus, to reduce the likelihood of false-positive findings, replication is essential. We were able to successfully replicate the findings of previous field studies (e.g., Fischer et al., 2018; van Dyck et al., 2005) in an experiment under standardized conditions. Moreover, we were able to extend these results by successfully manipulating error management culture.

Nonetheless, while our study has a lot of strengths, we believe that some questions remain to be answered. First, it remains to be tested whether our intervention for inducing error management culture can also be applied in organizations where teams presumably have an established error culture. The question remains whether our interventions are strong enough to overrule already established norms and practices of how to deal with errors. Second, as the effect of our manipulation on error management culture (as perceived by the team) was only durable for a second team task when culture strength was high, future research could probe whether reminding participants of our manipulations or strengthening our manipulations would lead to longer-lasting effects. Third, as our teams only worked together for a short period of time, future research could investigate teams for a longer period of time. This would give organizations an idea about how long interventions regarding a cultural change should be in effect. Fourth, in recent years, virtual teams, “groups of geographically and/or organizationally dispersed coworkers that are assembled using a combination of telecommunications and information technologies to accomplish an organizational task”, have arisen (Townsend, DeMarie, & Hendrickson, 1998, p. 18). It remains to be tested whether our results also apply to virtual teams, where communication may be not as rich (Hightower, Sayeed, Warketin, & McHaney, 1998) and more restricted than face-to-face communication. This is due to time lags (e.g., e-mail) in communication and fewer possibilities for informal communication. Conflicts that potentially arise in such teams are harder to resolve (Blackburn, Furst, & Rosen, 2003), as

team members cannot rely on traditional social cues and mechanism (Montoya-Weiss, Massey, & Song, 2001) and there is a greater potential for misunderstandings (Sproull & Kiesler 1986). Fifth, the present study does not shed light on underlying processes of the error management culture and performance relationship. We strongly encourage future studies to investigate potential underlying mechanisms of the error management culture-performance relationship. Given that error communication represents one of the most important practice of error management culture (van Dyck et al., 2005), we believe that communication may be a key variable.

Practical Contributions

We believe that the results of our studies are highly relevant for practitioners. Our findings of the beneficial effects of error management culture on performance highlight the importance to include error management culture in organizational development programs. Furthermore, our study sheds light on how difficult it is to induce an error management culture in teams. While it is relatively easy to persuade someone to follow instructions and behave according to them in the short-term, changing deeper rooted beliefs and values about something might be more difficult and a longer process. This is particularly important for understanding the drivers of organizational development and change processes.

We encourage organizations to explicitly include the topic of errors and error management in their ongoing leadership and employee development programs (e.g., in modules on error management in leadership training) specifically directed at improving error management culture. Such an intervention should explore the topic of error management culture and cover different aspects of the principles of error management culture. As our results showed, encouraging participants to explore, experiment, and learn from errors may benefit the team's perception of error management culture, and improve their performance. Thus, these aspects should be stressed particularly in an intervention with the goal of establishing error

management culture. Also, participants should be confronted with the topic over and over again and should actively take part in problem-solving tasks related to the topic. Thereby, participants have to interact and can commonly learn new practices and values in line with error management culture. Moreover, the leader (or founder) of the team should take an active role in the emergence or change process. Changing the deeper assumptions of members using an external force may not be as successful as when the values and beliefs of an interacting leader (and group member) are stressed.

In our experiment with newly formed teams, we successfully manipulated teams' perception of error management culture by fostering exploration in an attempt to experimentally induce an error management culture. Furthermore, we experimentally replicated the beneficial effect of error management culture on performance found in field studies in a creative problem-solving task. We believe that our study provides important implications and starting points for both theory and practice regarding error management culture.

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Part III

General Discussion

5

Overall Conclusion, Implications, and Future Directions

“From error to error, one discovers the entire truth.”

(Sigmund Freud)

The topic of learning from errors at work is increasingly gaining attention in applied psychology and management research. While scholars agree that errors can be a rich source of learning (e.g., Dormann & Frese, 1994; Edmondson, 1996; Ellis, Carette, Anseel, & Lievens, 2014; Frese & Keith, 2015; Heimbeck, Frese, Sonnentag, & Keith, 2003; Ivancic & Hesketh, 1995/1996; Keith & Frese, 2008; Madsen & Desai, 2010; Zakay, Ellis, & Shevalsky, 2004), little is known about the error characteristics and contextual factors that may affect the amount of learning from errors. The first aim of this dissertation was to investigate the role of error characteristics and contextual factors in learning from errors. In particular, our first category of research questions asked whether the amount of learning from errors depends on the severity of error consequences, the agent who made the error, the organizational culture (e.g., error management culture), and if there are differences between

countries in learning from errors. We addressed the first category of our research questions in Chapter 2 and Chapter 3 of this dissertation.

In Chapter 4, we shifted our focus from learning from errors to error management culture and addressed the second category of our research questions. Previous field studies have shown that error management culture benefits organizational outcomes, such as safety, innovativeness, and performance (Hofmann & Mark, 2006; Keith & Frese, 2011; van Dyck, Frese, Baer, & Sonnentag, 2005; Fischer, Frese, Mertins, & Hardt-Gawron, 2018). The question, however, remained, whether it is possible to induce an error management culture and if so, how. The second aim of this dissertation was therefore to explore whether and how we can induce an error management culture in teams.

Summary of Results

In Chapter 2, we reported two studies in which, by means of two vignette experiments, we investigated the assumptions that more learning occurs from errors with severe consequences as opposed to mild consequences, and when the error was made by oneself as opposed to by someone else. As expected, people learned more from errors in terms of affective error learning and cognitive error learning if consequences were severe (Study 1 and 2) and if the error was made by themselves (Study 2).

In Chapter 3, we tested the assumption that more learning from errors occurs (in terms of affective error learning) when more error management culture is experienced. Furthermore, we investigated whether there are country differences in learning from errors and if so, whether error management culture mediates the relationship between country and learning from errors. We also aimed at replicating the pattern of results regarding severity of error consequences and agent found in Chapter 2. To test our assumptions and research questions, we conducted vignette experiments in three different countries: the United States, Hungary, and Germany. As expected, people learned more from errors if consequences were severe, if the error was

made by themselves, and when more error management culture was experienced. Furthermore, we found differences between countries in that participants from the United States learned more from errors than participants from Hungary or Germany. This relationship was mediated by error management culture.

In Chapter 4, we shifted the focus from the individual to the team level and tested our second category of research questions. In particular, we tested whether the beneficial effects of error management culture not only apply to learning from errors (as shown in Chapter 3), but also to performance-related outcomes such as performance in a creative problem-solving task. Furthermore, we tested whether it is possible to induce error management culture in teams. To test our assumptions and research questions, we conducted a laboratory experiment with newly formed teams, in which we aimed to induce an error management culture. Furthermore, we tested whether we would also find the beneficial effect of error management culture on performance reported in previous field studies (e.g., van Dyck et al., 2005; Fischer et al., 2018), under standardized experimental conditions. We were able to successfully manipulate error management culture (as perceived by the team) in teams by fostering exploration and learning from errors. Furthermore, we found error management culture to be beneficial for performance in a creative problem-solving task. However, these effects persisted over time only when culture strength (i.e., agreement about culture between group members) was high. In the next sections, we discuss our results in greater detail and provide theoretical and practical implications, and future research directions.

Theoretical and Practical Implications

This dissertation addressed research questions concerning error characteristics and context factors that support learning from errors, and performance effects of an error management culture in teams. Our results regarding learning from errors indicate that not the error per se and its informational value determines whether people use it for learning, as

hypothesized by some researchers (e.g., Ivancic & Hesketh, 2000; Heimbeck et al., 2003; Sitkin, 1992). Rather, relatively superficial error characteristics and context factors, such as the severity of the error consequence, the agent who made the error or the perceived organizational culture (e.g., error management culture), affect learning from errors. Our studies regarding learning from errors (Chapter 2 and Chapter 3) go beyond previous research and contribute to the existing literature in the following ways. First, our studies add to the relatively scarce body of research concerning error characteristics and contextual factors that may affect learning from errors (Homsma, van Dyck, De Gilder, Koopman, & Elfring, 2009; Zakay et al., 2004). Second, previous field studies remained inconclusive in regard to causality. We addressed this issue by using an experimental vignette-methodology. Third, we considered factors that go beyond the error itself, such as the context in which the error was made.

Understanding which factors (i.e., error characteristics or contextual factors) affect learning from errors enables taking advantage of the learning potential of errors. Organizations may develop interventions that explicitly address the topic of errors and actively encourage learning from errors. To fully exploit the learning potential inherent in errors, organizations should raise attention towards errors with mild consequences and errors made by others. As our results showed, errors with mild consequences and errors made by others do not attract as much attention, and thus do not lead to as much learning as errors with severe consequences or errors made by oneself. Furthermore, our results highlight the importance of error management culture (as perceived by the team) for learning from errors. Organizations should foster an error management culture, a culture in which errors may be openly discussed and are considered as a chance to learn. Organizations should also take into account culture and country specific characteristics, norms, and habits, as our results showed that countries differ in the amount of learning from errors.

To the best of our knowledge, we are among the first ones that aimed at inducing an

error management culture in teams under standardized conditions. By studying how an error management culture can be induced, we aimed to (a) shed light on how the concept of error management culture manifests in teams, and (b) answer questions regarding the drivers of change and innovation effects. Furthermore, (c) our results should benefit practitioners, as they give starting points for effective interventions that aim at inducing error management culture in teams and organizations. By using an error management culture manipulation based on error management instructions, that is, encouraging participants to explore, experiment, and learn from errors, we managed to manipulate error management culture (as perceived by the team) in our study. However, the effect persisted over time (that is, for a second team task) only when culture strength (Schneider, Salvaggio, and Subirats, 2002) was high. Establishing a culture (i.e., shared norms, practices) may be more difficult than previous research indicates (e.g., Sherif, 1935; Tajfel, 1970). This has important implications both for social psychological and organizational culture research and also for practice regarding organizational culture change.

Our results regarding the beneficial effect of error management culture on team performance in a creative problem-solving task are in line with empirical evidence that suggests error management culture to be beneficial for organizational outcomes such as safety, innovativeness, and performance in terms of firm profitability (e.g., Fischer et al., 2018; Hofmann & Mark, 2006; Keith & Frese, 2011; van Dyck et al., 2005). In this respect, our study experimentally replicates the findings of previous correlational field studies. Nonetheless, our results should be considered to be a complement to previous correlational research for the following two reasons. First, by investigating error management culture experimentally under standardized conditions, it is possible to establish causality (Shadish, Cook, & Campbell, 2002) and take into account confounding factors that can hardly be avoided in field research. Second, our study investigated newly formed teams instead of “traditional” teams, as did previous studies. In a rapidly changing world, new teams are formed quite often, and changes in team

structure are common. It is therefore particularly important to investigate teams in which a culture is not yet established. Our results showed that newly formed teams can also benefit from the favorable effects of error management culture.

In sum, we showed that error management culture is not only beneficial for learning from errors, but also for performance. Again, we encourage organizations to develop interventions that aim at inducing error management culture, and also to explicitly include the topic of errors and error management in their ongoing development programs. Such interventions should introduce the concept of error management culture and explore different aspects of the principles of error management culture. The interventions should also discuss which error, person, and organizational characteristics are beneficial or a hindrance to constructively dealing with error. Furthermore, they should also introduce different strategies on how these hindrances can be overcome. We provide a starting point that outlines which interventions in organizational development programs should be considered and included.

Future Research Directions

Although the research presented in this dissertation provides several theoretical, empirical, and practical implications, it also leads to new research questions that remain to be answered. Regarding learning from errors, we encourage future research to develop a learning measure that on the one hand allows to be employed in standardized settings such as experiments, but on the other hand has higher ecological validity than the measures we employed (self-reports and recall of error situations) in our studies in Chapter 2 and Chapter 3. Future research may also investigate other error characteristics than severity of error consequences and agent that may affect learning. Errors may differ with regard to the richness of the information inherent in errors or with regard to the type of lesson to be learned. Future research may also explore the role of person attributes in learning from errors, such as neuroticism. We suggest that people who are high on neuroticism will feel particularly

threatened by errors they make. This increased threat could lead to maladaptive reactions including rigidity and defensiveness. This could, in turn, impede learning. Future studies are also encouraged to investigate learning from errors in other countries than the countries examined in this dissertation to broaden the knowledge about country specific issues.

In regard to our results that error management culture positively relates to performance in teams, it remains to be tested which intervening processes underlie this relationship. We suggest communication to be a potential mediator of the error management culture-performance relationship. In teams high in error management culture, team members should not fear blame for unconventional or erroneous statements. Such statements may foster innovative ideas, and the innovative ideas may enhance the team's performance. We also encourage future studies to investigate whether the beneficial effect of error management culture on performance also applies to other sort of tasks, for example, tasks that require rational problem-solving instead of creative problem-solving.

Also, more research is needed regarding how an error management culture can be induced. Our instructions give a starting point for a successful intervention that aims at establishing error management culture. It remains to be tested whether our manipulations could also be applied to induce an error management culture in teams that already have an established error culture. In addition, it is not clear whether our interventions are strong enough to overrule an already established error culture. Moreover, future research could investigate facilitating person characteristics (e.g., personality traits) and team characteristics (e.g., team reflexivity) for inducing an error management culture.

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Appendix A

An example of a vignette (error situation) we presented participants

You/A close colleague of yours/An employee of a competing company have/has to hold a presentation in front of a customer. Depending on the outcome of the talk, you/he/she can count on an acquisition. You/he/she make/makes the following mistake. Despite your/his/her preparation, you/he/she cannot answer the customer's questions adequately. The customer is thus very dissatisfied with the performance of the company.

Mild error consequence:

However, the customer gives you/your close colleague/the employee of the competing company some time and you/he/she can submit the answers within the next few days.

Severe error consequence:

The customer is so dissatisfied with you/your close colleague/the employee of the competing company that the acquisition does not happen.

Appendix B

Manipulations used in Chapter 4

Error management culture manipulation based on error management training instructions

German (original) version	English (translated) version
<p>Machen Sie bei der Aufgabe so viele Fehler wie möglich! Fehler sind etwas Gutes! Denn aus Fehlern können Sie lernen! Probieren Sie immer wieder aus, ob der Turm schon stabil genug für den Marshmallow ist. Falls der Turm den Marshmallow noch nicht tragen kann – freuen Sie sich, denn Sie können aus Ihren Fehlern lernen! Besprechen Sie in der Gruppe, was Sie falsch gemacht haben, und gehen Sie offen mit Fehlern um. Nur so können Sie aus Ihren Fehlern lernen. Sie können 10 Minuten lang herumprobieren– Sie bekommen sogar immer wieder 20 neue Spaghetti! Sie können also verschiedenste Konstruktionen ausprobieren. Je mehr Sie ausprobieren, desto mehr Fehler werden Sie machen – und je mehr Fehler Sie machen, desto besser können Sie werden! So können Sie es schaffen, den höchsten Turm zu bauen!</p>	<p>Make as many errors as you can while working on the task! Errors are a good thing as you can learn from them! Test again and again whether the structure is already stable enough to hold the marshmallow. If the structure cannot yet carry the marshmallow - be happy because you made an error, and from your errors you can learn! Discuss in your group what went wrong. Be open about dealing with errors. This is the only way to learn from your errors. You can try around for 10 minutes - you even get 20 new spaghetti every time! Thus, you can try out a variety of constructs. The more you try around, the more errors you will make - and the more errors you make, the better you can get! This way you will be able to build the tallest structure!</p>

Error management culture manipulation based on normative social influence

German (original) version	English (translated) version
<p>Machen Sie bei der Aufgabe so viele Fehler wie möglich! Fehler sind etwas Gutes! Denn aus Fehlern können Sie lernen! In vorigen Durchgängen dieser Challenge haben wir uns angesehen, was die erfolgreichsten Gruppen - also die, die höchsten Türme gebaut haben - ausgemacht hat. Dabei haben wir gesehen: Die erfolgreichsten Gruppen haben am meisten ausprobiert und am meisten Fehler gemacht! 90% der erfolgreichsten Gruppen haben offen über Fehler diskutiert. So war es möglich, als Team aus Fehlern zu lernen und sich weiter zu verbessern. Und das gilt nicht nur für die Marshmallow-Challenge; Studien haben gezeigt, dass auch Unternehmen, die Fehler als Lernchance sehen, wesentlich erfolgreicher sind. Fehler führen zu kreativen Ideen, zu Innovationen, und somit zu besseren Leistungen! Wenn auch Ihr Team Fehler als etwas Hilfreiches betrachtet, können Sie es schaffen, den höchsten Turm zu bauen!</p>	<p>Make as many errors as you can while working on the task! Errors are a good thing as you can learn from them! In previous rounds of this Marshmallow Challenge, we had a look at what constituted the most successful groups. We saw that the most successful groups made the most trials and also made the most errors! 90% of the most successful groups openly discussed errors. That way it was possible to learn from errors as a team and to improve further. This does not only apply to the Marshmallow Challenge; Studies have shown that companies that see errors as a learning opportunity are much more successful. Errors lead to creative ideas, to innovations, and thus to better performance! If your team sees errors as helpful, you will be able to build the tallest structure!</p>

Error prevention culture manipulation

German (original) version	English (translated) version
<p>Versuchen Sie, von Anfang an alles richtig zu machen. Fehler behindern Sie bei der Arbeit. Es kostet Zeit und Energie, die Ursachen für Fehler zu suchen. Fehler verursachen Stress – unnötiger Stress, der vermeidbar ist! Sie sollten also am besten gar keine Fehler machen. Konzentrieren Sie sich stattdessen direkt darauf, den höchsten Turm zu bauen. Wenn doch etwas schief läuft, verschwenden Sie keine Zeit mit dem Fehler. Als Sieger-Team brauchen Sie das gar nicht! Die besten Teams machen immer alles richtig. So auch Sie: Machen Sie von Anfang an alles richtig, dann wird Ihr Turm auch der höchste werden!</p>	<p>Try to do everything right from the beginning. Errors hinder you at working. It takes time and energy to find the causes of errors. Errors cause stress - unnecessary stress that could be avoided! It would be best if you wouldn't make any errors at all. Instead, focus on building the tallest structure immediately. If something goes wrong, don't waste time on the error. As a winning team, you don't need that! The best teams always do everything right. Thus, you too: Do everything right from the start, and your structure will be the tallest structure!</p>

Appendix C

List of variables assessed in Chapter 2

(with additional variables assessed for exploratory purposes)

Construct	Measure/source	Study	Comments
<i>Dependent variable (DV)</i>			
Affective error learning	Learning from errors subscale of the Error Orientation Questionnaire (Rybowiak et al., 1999)	1, 2	We used three of 4 items of the subscale
Cognitive error learning	Recall task with guiding questions (we asked for the error and the situational context in which it occurred as well as the error consequences)	1, 2	Self-developed
Cognitive error learning	Cued recall task with multiple-choice test items (self-developed)	1	Originally, we had planned to additionally include multiple-choice test items in Study 1 but the items were too easy (75 to 90% correct answers across conditions) and produced ceiling effects. Multiple choice items were presented after the free recall task
<i>Person characteristics/traits</i>			
Negative affectivity	PANAS (Watson et al., 1988)	1, 2	German version by Krohne et al. (1996)
Cognitive ability (numerical skills, spatial-visual skills)	Satow (2017)	1, 2	Freely available German cognitive ability test. Was used as a filler task. In Study 2 we only used the subscale numerical skills
Error orientation (learning from errors)	Error Orientation Questionnaire (Rybowiak et al., 1999)	1, 2	We only used the subscale learning from errors. Partial overlap of item content with DV

Conscientiousness (Big Five)	BFI (John & Srivastava, 1999)	1, 2	BFI German version by Lang et al. (2001)
Neuroticism (Big Five)	BFI (John & Srivastava, 1999)	1, 2	BFI German version by Lang et al. (2001)
<i>Climate/culture perceptions</i>			
Error management culture	van Dyck et al. (2005)	1, 2	Partial overlap of item content with DV
<i>Other</i>			
Manipulation checks	Three self-developed items: e.g., “How negative do you evaluate the described situation?”	1, 2	One Kunin Item (Kunin, 1955)
Bogus items	Meade & Craig (2012)	2	

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Appendix D

List of variables assessed in Chapter 3

(with additional variables assessed for exploratory purposes)

Construct	Measure/source	Comments
<i>Dependent variable (DV)</i>		
Affective error learning	Learning from errors subscale of the Error Orientation Questionnaire (Rybowiak et al., 1999)	We used three of 4 items of the subscale
Blaming after an error	One item from Edmondson (1999) and four self-developed items	
Planning (secondary error prevention)	Three self-developed items	
Defensiveness (self- and other-blame)	CERQ (Garnefski & Kraaij, 2007)	We only used the subscales self-blame and blaming others
Working harder intentions	Raver et al. (2012)	We used three of 6 items
<i>Person characteristics/traits</i>		
Negative affectivity	PANAS (Watson et al., 1988)	German version by Krohne et al. (1996). Hungarian version by Rózsa et al. (2008)
Error orientation (learning from errors)	Error Orientation Questionnaire (Rybowiak et al., 1999)	We only used the subscale learning from errors. Partial overlap of item content with DV
Conscientiousness (Big Five)	BFI (John & Srivastava, 1999)	BFI German version by Lang et al. (2001)
Neuroticism (Big Five)	BFI (John & Srivastava, 1999)	BFI German version by Lang et al. (2001)
Goal orientation	VandeWalle (1997)	German version by Heimbeck et al. (2003). We only used the subscales learning and avoid goal orientation
Perfectionism	Frost Multidimensional Perfectionism Scale (Frost et al., 1990)	German version by Stöber (1995). We only used the subscale concern over mistakes and two items of the subscale doubt
Competitiveness	Competitiveness Index (Houston et al., 2002)	

Implicit theory of ability	Chiu, Hong, & Dweck (1997)	German version by Spinath & Schöne (2003)
<i>Climate/culture perceptions</i>		
Error management culture	van Dyck et al. (2005)	Partial overlap of item content with DV
Psychological safety	Edmondson (1999)	German version by Baer & Frese (2003)
Blaming culture	Gao et al. (2014)	
Error prevention culture	Four items from Gao et al. (2014) and seven self-developed items.	
Planning for uncertainty	Skorka (2006)	
Uncertainty avoidance	GLOBE (House et al., 2004)	
<i>Other</i>		
Manipulation checks	Two self-developed items: e.g., "How negative do you evaluate the described situation?"	
Authenticity check	Three self-developed items: e.g., "I perceived the depicted error situation as realistic."	
Bogus items	Meade & Craig (2012)	

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Appendix E

List of variables assessed in Chapter 4

(with additional variables assessed for exploratory purposes)

Construct	Measure/source	Comments
<i>Dependent variable (DV)</i>		
Team performance (Task 1)	1) Height of the structure (cm) 2) Did the structure collapse or not (in 30 seconds)	Objective measures
Team performance (Task 2)	1) Height of the structure (cm) 2) Number of pieces used for construction 3) Running time of marble (sec)	Objective measures
<i>Person characteristics/traits</i>		
Error orientation	Error Orientation Questionnaire (Rybowiak et al., 1999)	
<i>Climate/culture perceptions</i>		
Error management culture (Task 1 and Task 2)	van Dyck et al. (2005)	Partial overlap of item content with DV
Error aversion culture (Task 1 and Task 2)	van Dyck et al. (2005)	
Culture or climate strength (Task 1 and Task 2)	$r_{wg(j)}$ (James, Demaree, & Wolf, 1984, 1993)	
<i>Other</i>		
Manipulation check: Number of trials (Task 1 and Task 2) (second manipulation check)	We counted the number of trials participants needed till they arrived at the final solution	Objective measure
Goal commitment	Hollenbeck, Williams, & Klein (1989)	We only used three items of the scale
Task familiarity (Task 1 & Task 2)	Three self-developed items: e.g., “Were you familiar with the “Marshmallow Challenge/marble run” task?”	Due to poor reliability one item was deleted from the scale
Familiarity with team members	One self-developed item: “How well do you know the two other members of your group?”	

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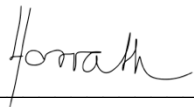
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Obligatory Declaration

I declare that I have developed and written the enclosed doctoral dissertation entitled “Learning from Errors and Error Management Culture in Teams” completely by myself, and have not used sources or means without declaration in the text. Any thoughts from others or literal quotations are clearly marked. This thesis was not used in the same or in a similar version to achieve an academic grading or is being published elsewhere.

Darmstadt, 31/03/2020



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